Report No. 5

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SECOND ANNUAL REPORT OF THE SCIENTIFIC AND INDUSTRIAL RESEARCH COUNCIL OF ALBERTA

PRINTED BY ORDER OF THE LEGISLATIVE ASSEMBLY

EDMONTON:
PRINTED BY J. W. JEFFERY, KING'S PRINTER
1922

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University of Alberta,
Edmonton, Alberta.
February 11th, 1922.

Hon. Herbert Greenfield,
Provincial Secretary,
Edmonton, Alta.

Sir:—

Under instruction from the Scientific and Industrial Research Council of Alberta, I herewith submit their Second Annual Report. This covers the work done under their direction during the year ending December 31st, 1921.

Respectfully submitted,

Edgar Stansfield,
Honorary Secretary.

SECOND ANNUAL REPORT OF THE SCIENTIFIC AND INDUSTRIAL RESEARCH COUNCIL OF ALBERTA

PERSONNEL OF COUNCIL

The following changes have been made during the year:—

In September Hon. J. L. Coté resigned from the Chairmanship and his place has been taken by Premier Herbert Greenfield in his capacity as Provincial Secretary.

In October Dr. J. A. Allan resigned as Honorary Secretary of the Council and E. Stansfield was appointed to take this position.

The personnel on December 31st, 1921, was as follows:—
Hon. Herbert Greenfield, Provincial Secretary, Chairman;
H. M. Tory, President, University of Alberta;
J. T. Stirling, Chief Inspector of Mines, Province of Alberta;
J. A. Allan, Geologist, University of Alberta;
N. C. Pitcher, Mining Engineer, University of Alberta;
Edgar Stansfield, Honorary Secretary.

STAFF

The following changes have been made during the year:—

E. Stansfield took up his duties as Chief Chemical Engineer in April, R. T. Hollies was appointed Assistant Engineer in May, and the position of J. B. Coghill as Recording Secretary was confirmed in July. In addition seven persons have held short time or subordinate positions.

The Staff on December 31st, 1921, was as follows:—
Edgar Stansfield, Research Engineer, *Fuels;*
K. A. Clark, Research Engineer, *Road Materials;*
R. T. Hollies, Assistant Research Engineer, *Fuels;*
J. B. Coghill, Recording Secretary to the Council;
T. Holmes, Laboratory Assistant.

In addition to the above, Professors J. A. Allan and N. C. Pitcher of the University of Alberta, members of the Council, are in permanent charge of the Council's research work in Geology and in Mining Engineering, respectively.

Other members of the University Staff, notably Professors Kelso, Robb and Wilson, are giving assistance from time to time, and two demonstrators in Mining Engineering, R. T. Hollies, during the 1920-1921 session, and J. W. Lewis, during the 1921-1922 session, gave much of their time to the Council's research on fuels.

ORGANIZATION

In the organization of the University of Alberta the staff of the Research Council constitutes the Industrial Research Department, and the Research Council's laboratories are referred to as the Industrial Research Laboratories.

In the organization of the Provincial Government the work of the Research Council is attached to the Department of the Provincial Secretary.

LABORATORIES AND EQUIPMENT

In January, an agreement was entered into between the Board of Governors of the University and the Research Council to govern the conditions under which the work of the Research Council was to be carried out at the University. In accordance with this agreement the University has reserved four rooms, with part of a fifth, exclusively for research under the direction of the Council. In addition, laboratory accommodation and the general facilities of the University have been of great assistance in the work undertaken. Thus, for example, screening tests and furnace tests have been carried out in the Mining Engineering laboratories and boiler trials in the University Power House. Three of the rooms mentioned above have now been fitted up as chemical and research laboratories, and much of the necessary general equipment has been purchased and installed. Further equipment is to be added as required.

Special apparatus for research on the air-drying of coals and also for the carbonization of lignite has been designed and constructed. Five domestic furnaces have been installed in the Mining Engineering laboratory—two hot air furnaces, two hot water furnaces and one jacket water heater.

The Calyx drill originally rented for the purpose of drilling for salt at Fort McMurray has now been purchased and is at present in storage at McMurray.

Some progress has also been made with building up a research reference library along the lines of work now in progress.

FUELS

The work on fuels described in the First Annual Report has been continued throughout the year, and fresh work undertaken along different lines. Eight carload samples of coal have been received and tested. The storage work is in full progress, and results of prolonged storage are now coming in. The experience gained has shown various ways in which this work can be improved, and made to give more valuable information. Tests in progress will be completed as before, but new methods will be employed in future. Screening tests have been made as before, also screen equivalency tests on all the carload samples received. Boiler trials have been carried out on all the large samples, also on one mixed coal. Fourteen trials in all have been made during the year.

House heating furnace tests have been made on a number of coals in the different types of furnaces available. These have been mainly of a preliminary nature, with the idea of perfecting the equipment and the methods of firing and testing. Systematic tests will shortly be made on these furnaces.

A study has been made of the methods of coal sampling both at the mine and in the laboratory, as a consequence of which improved methods will be employed in the coming year.

An experimental carbonizer for lignites has been designed and constructed in the University workshops, and is now ready for operation.

In addition to the above, much of the time of the staff has been taken up with the designing and equipment of the laboratories, and the setting up and standardization of the apparatus. The laboratory was in constant use for fuel analysis, etc., for the last four months of the year. A detailed account of this work on fuels is given as an appendix.

GEOLOGY

The geological work for the Council was carried on in conjunction with the Department of Geology. During the year there has been an increased demand for information on various phases of the mineral resources of Alberta. Over one thousand letters were received and sent relating to the same. About four months were spent on field work. A party of five made a detailed study of a portion of the coal basin in the Drumheller district, and J. A. Allan also visited certain other districts. A brief summary of all this field work is given as an appendix to this report, and a full account of the Drumheller work is given by J. A. Allan in the "Third Annual Report on the Mineral Resources of Alberta," (1921).

MUSEUM

In addition to the University Geological Museum in the Arts Building, an exhibit of Alberta minerals and of products from these minerals is maintained by the Research Council in Room 209, Mining Engineering Building. This exhibit will be added to from time to time.

The complete rock core from the salt well drilled by the Alberta Government at Fort McMurray in 1920 was brought down from the well site and has been arranged in open exhibit cases in such a way that any portion of the core can be seen and studied with convenience.

ROAD MATERIALS

The work of the year has had as its primary object the development of an improved earth road suitable for the rural needs of the Province. As stone is not available in quantity, and bitumen

is, the latter is being carefully studied. Preliminary experiments have shown that, by adding bitumen from the Athabaska bituminous sand to clay soil, road aggregates can be obtained which are stable even when wet. Two research problems are involved in further progesss: first, the investigation and development of a feasible method of separating the bitumen from the sand in a form suitable for road work; and, second, the determination of the best method of combining the bitumen with the different types of soil in order to obtain the best road surface. Good progress has been made with the separation problem, and there is reason to hope that a simple commercial process may soon be perfected. Also a number of clay soil samples have been secured through the cooperation of the engineers of the Public Works Department, and these are to be used in a further and more detailed study of the possibilities of making good rural roads with the aid of bitumen. A detailed account of the problems involved in the development of the bituminous sand, together with a collection of data with regard to this sand and its bitumen, is given as an appendix.

SALT AT McMURRAY

The results of the prospecting by borings into the salt deposits at Fort McMurray, described in the First Annual Report, (1920), indicated that the conditions of development and mining would be somewhat similar to those in the Kansas salt field. Mr. N. C. Pitcher was sent to Kansas, therefore, to obtain information as to the best methods to use, the plant required, and the cost of opening and operating such mines. His report, which was made in February, is under consideration by the Government.

FOREST PRODUCTS

Professor R. S. L. Wilson is directing inquiries to many possible sources with a view to completing a collection of existing data pertaining to Alberta forest resources.

When the collection is completed, it is proposed to make a general study of the whole problem of the best use of these resources and to suggest such supplementary investigations as may be necessary.

COAL SAMPLES AND ANALYSES

Eight car load samples have been received during the year. These samples were taken, under the supervision of the District Inspector of Mines, to represent the regular output of the mine. Their analyses are given in the appendix. In addition to these large samples, the District Inspectors of Mines of the Province have taken during the year some 175 coal samples from 43 separate mines. These samples have been analysed for the Provincial Mines Branch

by Mr. J. Kelso, Provincial Analyst. As a matter of convenience, and by arrangement with Mr. J. T. Stirling, Chief Inspector of Mines, these analyses are given in the appendix beside the corresponding analyses of the car load samples. Details of the method of sampling and the significance of the results are also given.

ACKNOWLEDGEMENTS

The Jasper Park Collieries, the Blue Diamond Coal Co., the Foothills Coal Co., the North American Collieries, the Dobell Coal Co., the Humberstone Coal Co., and the Twin City Coal Co. materially assisted in the work on fuels, by each contributing a car load of their coal. It is hoped that other firms will be equally generous in the future, so that a careful study may be made of typical consignments from each of the coal areas of the Province.

The domestic heating furnaces on which tests are being made were contributed by the following:

The Gurney Foundry Co., Ltd., of Toronto, Ont.;
The Gravity Stoker Furnace Co., Ltd., of Winnipeg, Man.;
The McClary Manufacturing Co., Ltd., of London, Ont.;
Mr. R. W. King, of Toronto, Ont.

FUELS

BY N. C. PITCHER, E. STANSFIELD, R. T. HOLLIES AND J. W. LEWIS
(to which is added a Report on Boiler Trials by C. A. ROBB)

The work described below is a continuation of that outlined in the previous report, although its scope has been much wider.* The laboratory work was largely carried out by R. T. Hollies, but J. W. Lewis was responsible for the screening and storage tests, and the chemical analyses involved, after the middle of September. T. Holmes assisted in the laboratory throughout the year. During the earlier part of the year chemical analyses were made in the Provincial Industrial Laboratories of the University, but after the completion of our own laboratories, also at the University, all analytical work was done in the latter.

COALS TESTED

Nine carload samples of run of mine coal for screening, storage and boiler tests were received at the University during the year. With only two exceptions the coal was donated by the mine operators. A list of the coals, classified under their respective coal areas, follows:

Mountain Park Area:—
- Mountain Park Coal Co., Ltd., Mountain Park, Alta.
- Cadomin Coal Co., Ltd., Cadomin, Alta.

Jasper Park Area:—
- Jasper Park Collieries, Ltd., Pocahontas, Alta.
- Blue Diamond Coal Co., Ltd., Brule, Alta.

Yellowhead Pass Area:—
- Foothills Coal Co., Ltd., Foothills, Alta.

Pembina-Wabamun Area:—
- North American Collieries, Ltd., Pembina Mine, Evansburg, Alta.

Tofield Area:—
- Dobell Coal Co., Ltd., Tofield, Alta.

Edmonton-Clover Bar Area:—
- **Humberstone Coal Co., Ltd., Beverley, Alta.
- **Twin City Coal Co., Ltd., Edmonton, Alta.

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*First Annual Report of the Scientific and Industrial Research Council of Alberta (1920), pages 9 to 16. Report No. 3.

**These two samples were not inspected officially by a Provincial mines inspector before shipment to the University for tests.

Sampling

The coning and quartering method of sampling was used throughout the year. The larger lumps of coal were broken up with a tamper, but for further reduction in size the crusher and grinder in the Mining Engineering laboratories were employed. The crusher also acts as a sampler, as it cuts the material crushed into two equal portions.

Screening

This work is a continuation of that briefly described in the previous report. A small, working model, shaking screen has been

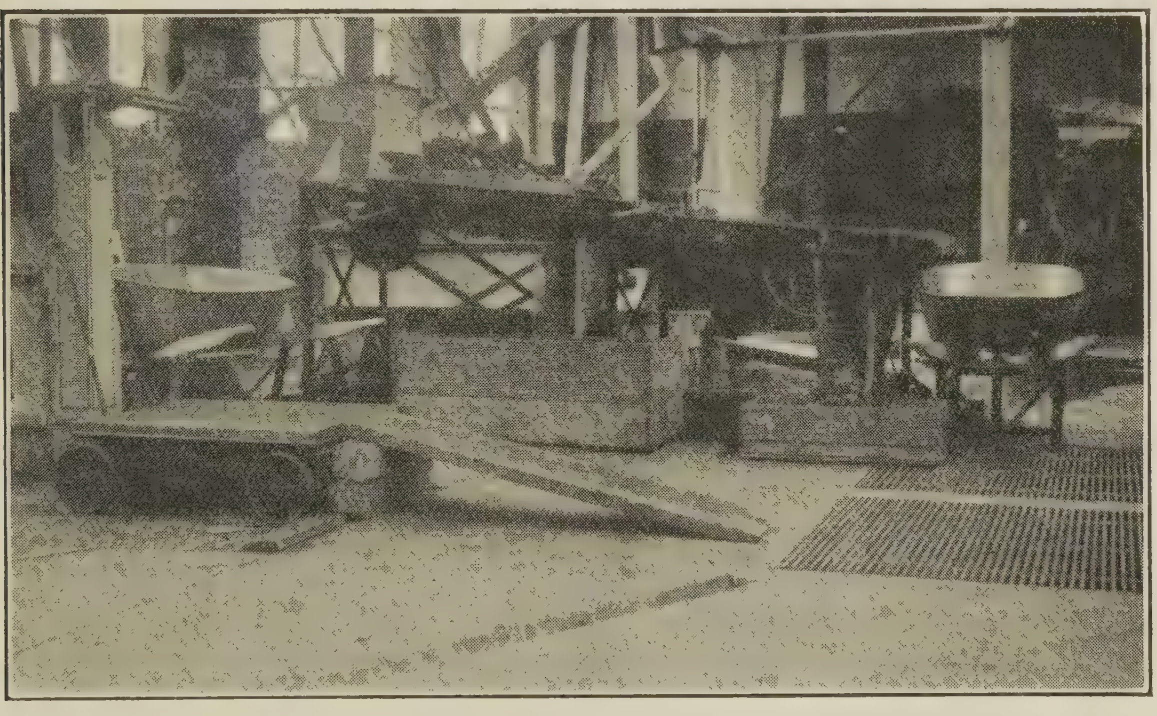
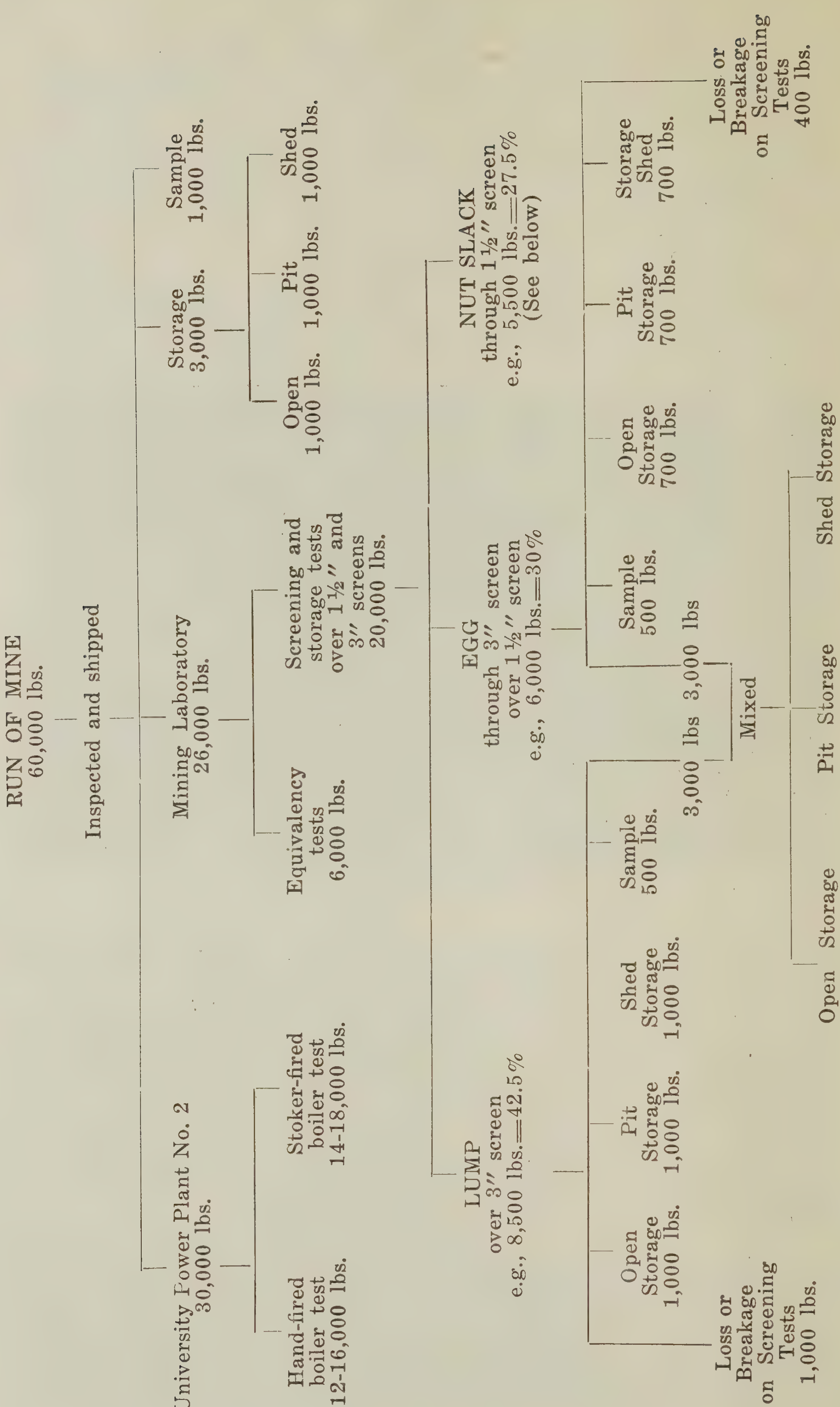


Fig. 1.—Shaking Screen.

used throughout. This is shown in Figure 1. The procedure followed in the screening tests, and also in the storage and other tests, is indicated by the flow sheet, Figure 2. The car of coal is placed on a railway siding near the University and unloaded by means of carts. About thirteen tons are delivered to the Mining Engineering laboratories, and the remainder to the University power house. A sample for chemical analysis is obtained by removing a shovelful at regular intervals as the carts are unloaded. The gross sample of some thousand pounds thus obtained is crushed, coned and quartered down to a laboratory sample. (See Figure 3).

Ten tons of coal are weighed and screened over 1½ inch and 3 inch perforated plates on the shaking screen. The lump, or oversize, the egg coal (through 3 inch and over 1½ inch) and the nut slack (through 1½ inch perforations) are collected separately and weighed, and the respective percentages of these in the original run of mine are calculated. The nut slack is rescreened over ¼ inch and ¾ inch


RUN OF MINE
60,000 lbs.
Inspected and shipped
University Power Plant No. 2
30,000 lbs.
Mining Laboratory
26,000 lbs.
Storage
3,000 lbs.
Sample
1,000 lbs.
Hand-fired
boiler test
12-16,000 lbs.
Stoker-fired
boiler test
14-18,000 lbs.
Equivalency
tests
6,000 lbs.
Screening and
storage tests
over 1½″ and
3″ screens
20,000 lbs.
Open
1,000 lbs.
Pit
1,000 lbs.
Shed
1,000 lbs.
LUMP
over 3″ screen
e.g., 8,500 lbs.=42.5%
EGG
through 3″ screen
over 1½″ screen
e.g., 6,000 lbs.=30%
NUT SLACK
through 1½″ screen
e.g., 5,500 lbs.=27.5%
(See below)
Open
Storage
1,000 lbs.
Pit
Storage
1,000 lbs.
Shed
Storage
1,000 lbs.
Sample
500 lbs.
Sample
500 lbs.
Open
Storage
700 lbs.
Pit
Storage
700 lbs.
Storage
Shed
700 lbs.
3,000 lbs
3,000 lbs
Mixed
Open Storage
Pit Storage
Shed Storage
Loss or
Breakage
on Screening
Tests
1,000 lbs.
Loss or
Breakage
on Screening
Tests
400 lbs.

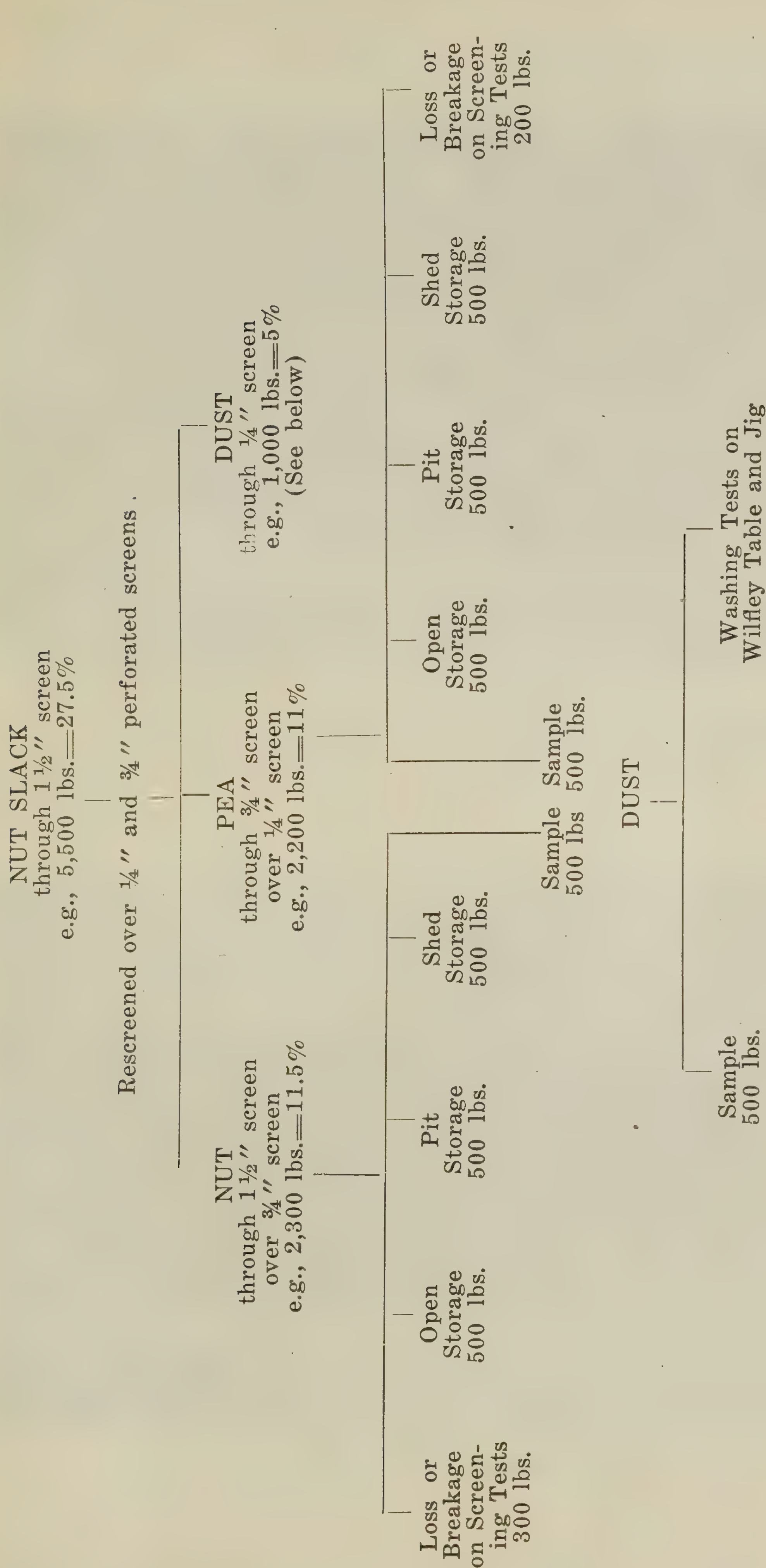


FIGURE 2.—FLOW SHEET OF TESTS

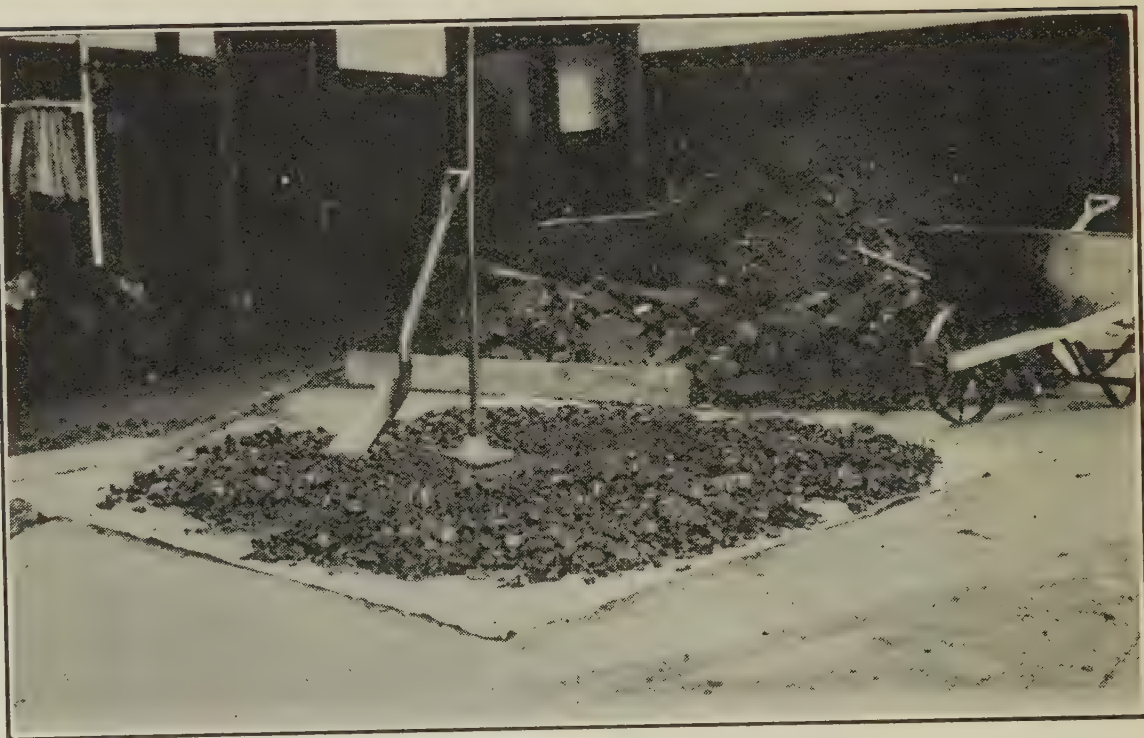


Fig. 3.—Coal Sampling.

Fig. 4.—Samples of Screened Coal.

perforated plates, and the products weighed. In this way the percentages of the nut coal (through 1½ inch and over ¾ inch), pea coal (through ¾ inch and over ¼ inch) and dust (through ¼ inch) in the original coal are determined. A small portion of each size is set aside at intervals during this screening operation. The samples thus collected are later crushed, coned and quartered in the usual way and then analyzed. Figure 4 shows piles of screened coal, with the corresponding samples in small boxes. Storage tests are carried out on the screened products as described later.

The breakage losses due to screening and handling are then determined by re-screening a half-ton sample of each size, and the percentage loss of each size, due to a reduction to a smaller size, is calculated. For example, 1,000 lbs. of lump, re-screened, gave 800 lbs. lump and 200 lbs. of smaller sizes, or a 20 per cent. loss. This screening loss is then deducted from the screening loss found after various periods of storage, and the net loss so calculated is assumed to have been produced by the deterioration of the coal due to weathering.

Table 1, below, shows at a glance the diameter of screen perforations adopted in this work for the different sizes of coal named. There is a large variation through the province, but the sizes stated represent the average value. Uniformity in this matter is extremely desirable.

TABLE 1.

	Through	Over
Lump	....	3 ″
Egg or Stove	3 ″	1½″
Nut	1½″	¾″
Pea	¾″	¼″
Dust	¼″	....
Slack	¾″	....
Nut Slack	1½″	....
Screened Coal	....	1½″

Table 2 shows, for a number of mines, the percentage of each size found in the run of mine coal after it had been delivered at the University. The percentage lump and fines in any consignment naturally will depend to a considerable extent on the handling it receives in transit as well as on its friability and its condition as it left the mine. The results of Table 2 are also shown graphically in Figure 5.

TABLE 2.

Standard Size	PERCENTAGE OF SIZES IN R. O. M.						
	Mountain Park	Pocohontas	Blue Diamond	Foothills	Pembina	Dobell	Twin City
Lump	10.5	2.5	1.4	48.3	43.4	58.7	44.6
Egg	8.2	5.6	4.5	17.2	19.7	23.8	29.9
Nut	6.3	6.0	5.8	11.7	11.4	8.2	10.2
Pea	22.0	20.7	25.6	14.7	16.4	6.3	10.7
Dust	53.0	65.2	62.7	8.1	9.1	3.0	4.6
Slack	75.0	85.9	88.3	22.8	25.5	9.3	15.3
Nut Slack	81.3	91.9	94.1	34.5	36.9	17.5	25.5
Screened Coal	18.7	8.1	5.9	65.5	63.1	82.5	74.5

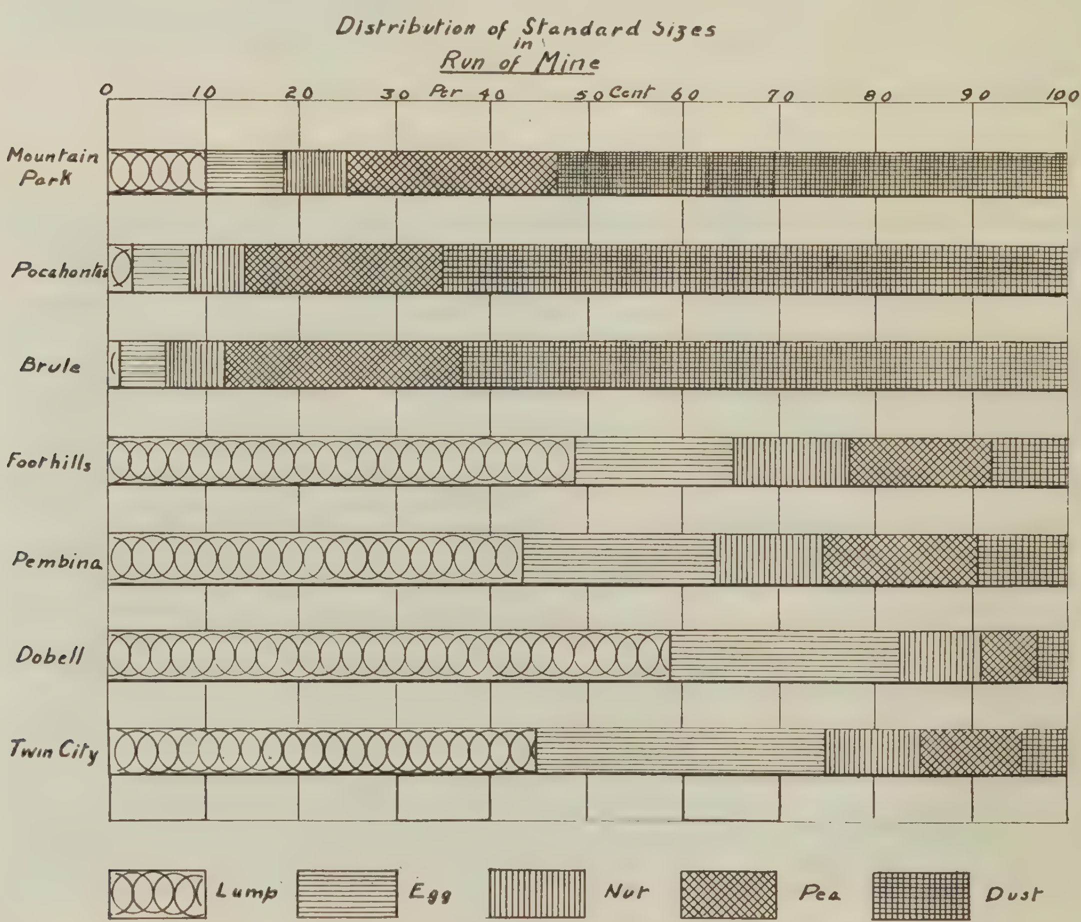


Figure 5.

Table 3 shows the percentage of ash found in each of the original run of mine coal samples, as well as in each sized product therefrom. The percentages are reduced to the dry coal basis.

TABLE 3.

Size	ASH PERCENTAGE (DRY BASIS) in R. O. M. and Standard Sizes of the Coals Named							
	Mountain Park	Cadomin	Pocahontas	Blue Diamond	Foothills	Pembina	Dobell	Twin City
R.O.M.	14.2	10.6	17.0	19.1	12.8	16.6	6.5	8.1
Lump	12.3	8.2	12.7	20.8	11.4	15.7	6.5	9.0
Egg	21.7	12.1	22.5	24.9	13.8	15.2	6.8	8.4
Nut	20.2	13.6	22.6	27.3	12.4	13.3	7.6	11.7
Pea	18.9	11.5	25.6	23.1	12.5	15.8	8.4	11.6
Dust	15.8	12.0	14.2	17.4	17.0	....	....	....

Equivalency tests were carried out on another portion of the original coal. These tests were to determine the bar screen spacings which must be employed with any coal to get the same percentage results, when the run of mine is screened, as those obtained with the perforated plate screens already referred to. Table 4 shows clearly the principal results obtained. The results obtained for the individual coals are averaged for the districts represented.

TABLE 4.

Diameter of Perforations of Plates	EQUIVALENT SPACING FOR BAR SCREENS for the Coal Areas Named					
	Mountain Park	Jasper Park	Yellow Head Pass	Pembina—Wabamun	Tofield	Edmonton—Clover Bar
	Measurements given in sixteenths of an inch.					
3 inches	29	28	28	32	26	33
2 inches	16	16	16	21	16	—
1½ inches	12	12	12	16	12	12
1 inches	8	8	8	11	8	—
¾ inches	6	6	6	8	6	8
¼ inches	3	3	3	3	3	3

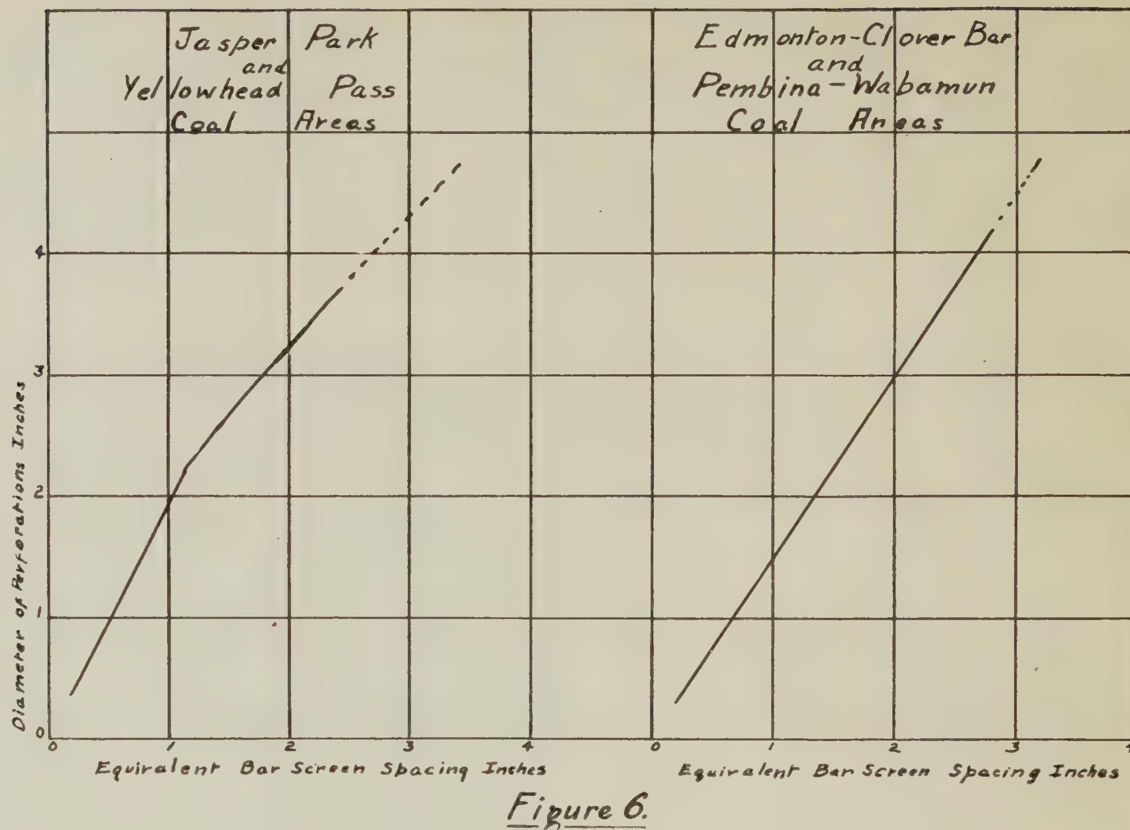


Fig. 6.—Equivalent Bar Screens and Perforated Screens: (a) Jasper Park and Yellowhead Pass Coal Areas; (b) Edmonton-Clover Bar and Pembina-Wabamun Coal Areas.

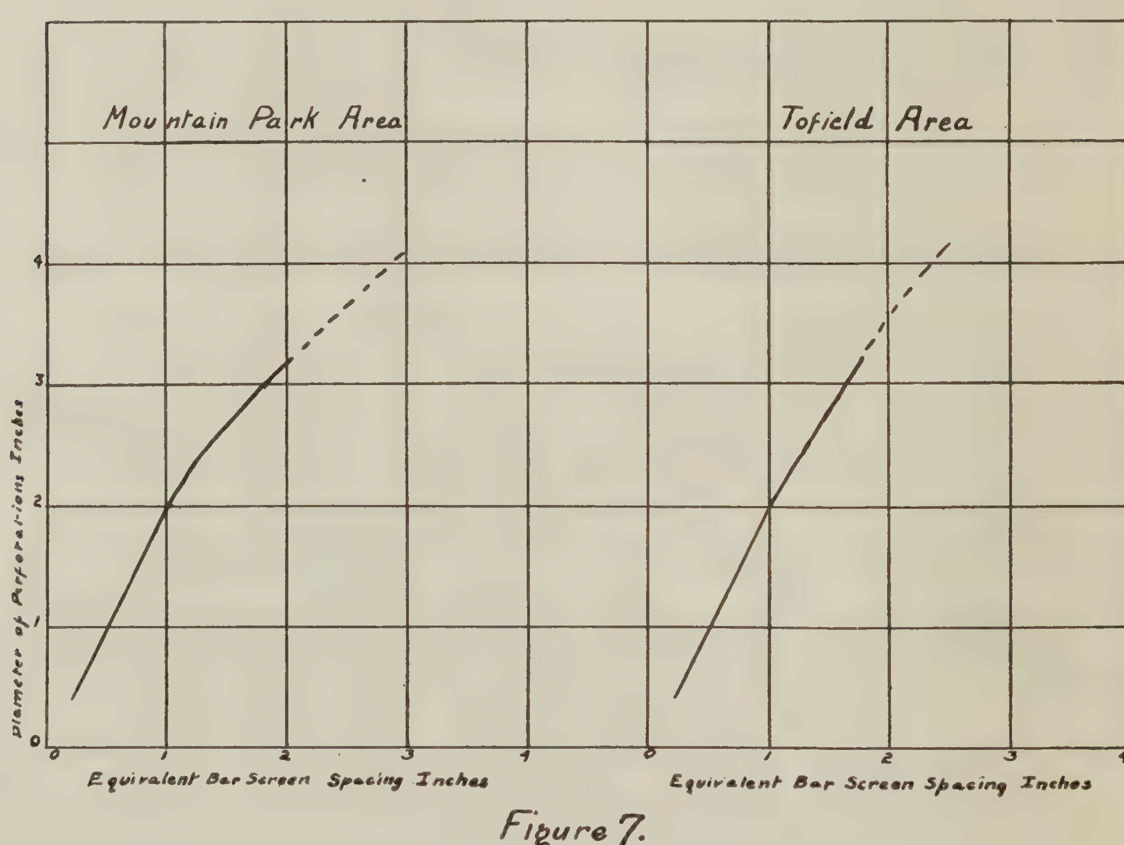


Fig. 7.—Equivalent Bar Screens and Perforated Screens: (c) Mountain Park Area; (d) Tofield Area.

Figures 6 and 7 show graphically the average equivalency results obtained with the coals from each of four areas.

In conclusion, it may be pointed out that the tests show that the percentages of screened coal in mine run delivered at the University vary from 6 to 20 per cent. with bituminous coal, and from 65 to 80 per cent. with domestic coal. The equivalency tests showed that the results obtained vary with the type of coal, but that a bar screen should have spacings not more than two-thirds or less than one-half the diameter of the perforations in a perforated screen in order to give the same percentage of sizes.

Storage

The programme of storage tests outlined in the previous report has been closely adhered to, although certain modifications were made during the year on account of lack of space. Thus, three storage compartments 14 feet by 11½ feet were obtained in another wooden shed, and the pit storage was modified to enable twice the number of samples to be stored. Figures 8, 9 and 10 show the shed, open and pit storage arrangements described in the earlier report. The programme for domestic coals is briefly as follows: Samples of run of mine coal and of the lump, egg, nut and pea sizes obtained in the screening tests are each stored in a shed, a pit and in the open. After one month, one quarter of each of the samples is brought in, rescreened and reanalyzed. The results show how much the sample has disintegrated and how much its chemical composition has changed, due to weathering. A second quarter of each sample is brought in and tested after six months, a third after one year, and the remainder after two years in storage. The programme for bituminous coal is similar to the above, but only run of mine coal is stored. Sixty-five domestic coal samples have been tested during the year after one month in storage, thirty-four samples tested after six months, and nine samples after one year in storage.

Fig. 8.—Coal Storage: Shed and Open Coal Piles.

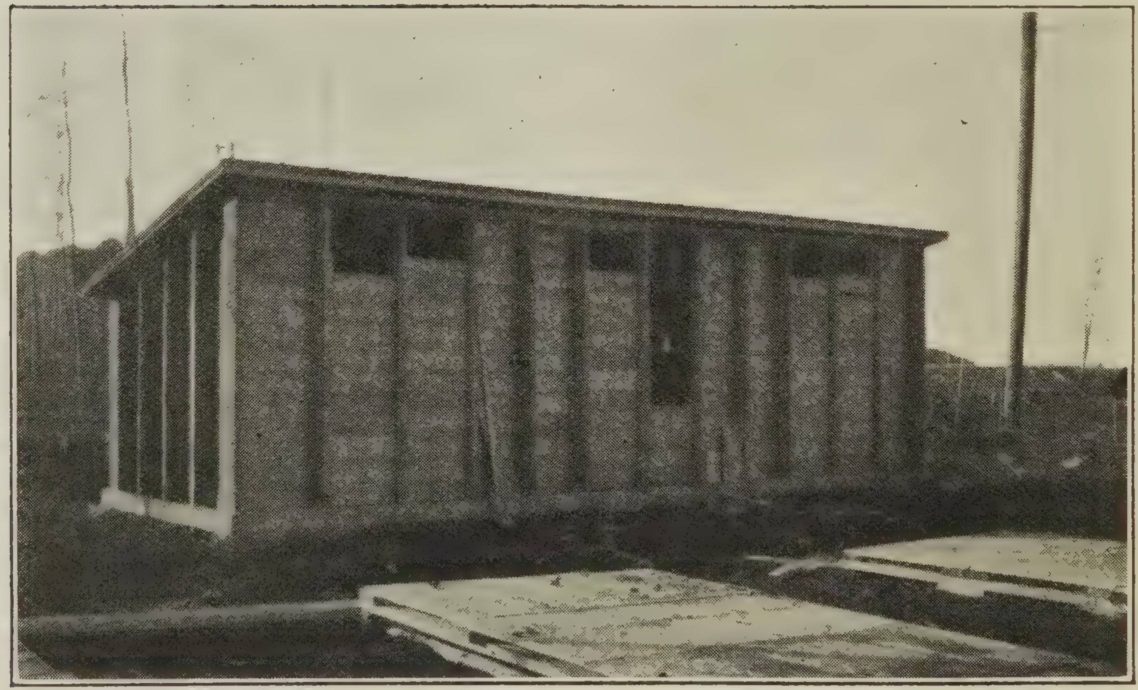


Fig. 9.—Coal Storage: Shed and Covered Pits.

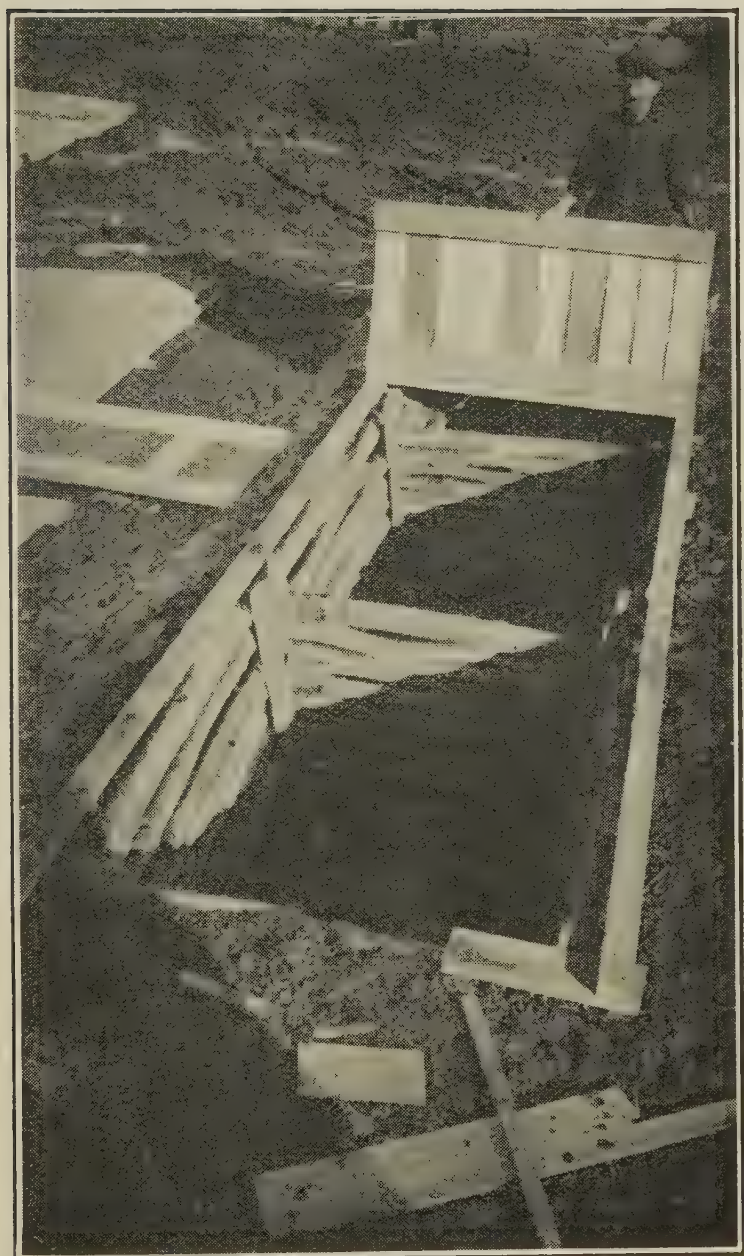


Fig. 10.—Storage Pits.

Table 5 shows the results obtained with respect to the disintegration of domestic coals. The chemical analyses so far obtained have not shown sufficient change, due to weathering, to warrant any conclusions being made at present.

TABLE 5.

Kind of Coal and Date First Stored	Size of Coal	PERCENTAGE BREAKAGE LOSSES DUE TO WEATHERING — After storage for One month in Open	One month in Pit	One month in Shed	Six months in Open	Six months in Pit	Six months in Shed	Twelve months in Open	Twelve months in Pit	Twelve months in Shed
Foothills Dec., 1921	Lump	0	0	15						
	Egg	20	0	0						
	Nut	15	15	5						
	Pea	5	5	2						
Pembina March, 1921	Lump	55	45	30	45	40	25			
	Egg	50	25	35	55	25	30			
	Nut	35	20	20	30	25	25			
	Pea	10	5	10	10	5	10			
Dobell Sept., 1921	Lump	30	25	30						
	Egg	....	40	20						
	Nut	....	20	30						
	Pea	....	5	5						
Humberstone Dec., 1920	Egg	0	5	2	40	15	30	40	20	20
	Nut	2	10	5	30	15	30	40	20	20
	Pea	1	5	5	10	0	5	20	5	15
Twin City Feb., 1921	Lump	30	20	15	50	20	20			
	Egg	25	25	25						
	Nut	20	25	15						
	Screened Coal	15	20	5	50	45	60			

The results indicate that although over a long period, such as six months, the disintegration is very similar with all coals of this type, the disintegration during the first month varies greatly with the weather. Changeable weather, especially alternations of freezing and thawing, seriously damages the coal, but dry, hot weather also makes the coal friable. Humberstone coal stored in the regular weather conditions of January showed less disintegration during the first month. Twin City coal, during the slightly less regular weather conditions of February, suffered more. Pembina coal, owing to the extremely variable weather conditions of March, showed the most disintegration; whilst Dobell coal dried out considerably during its first month of storage in September and thus became cracked and easily broken.

It is fully recognized that the present work on storage is only of a preliminary nature. The coals cannot be stored in large enough quantities or under sufficiently uniform conditions to enable definite conclusions to be drawn with regard to their commercial storage. Valuable information, however, has been obtained, and as a result of the year's work greatly improved methods will be used in 1922. It is hoped that when this preliminary work is completed large scale work can be carried out at the mine heads and at distribution centres without the costly mistakes that otherwise would inevitably have been made.

DOMESTIC FURNACES

Five domestic furnaces have been installed during the year. These, as shown in the accompanying photograph, figure 11, from left to right, are:—

1. Gurney hot water furnace;
2. Allan hot water furnace ;
3. Mogul water heater;
4. Sunshine hot air furnace; and
5. R. W. King hot air furnace.

The photograph also shows some of the testing appliances attached, such as an air measuring box above the Sunshine furnace and a number of thermometers, draft gauges, etc. The work in this case, also, has been largely of a preliminary nature. Tests were made to ascertain the air flow through the hot air heaters, and the suctions and temperatures to be expected in different parts of the installation. Air measuring boxes and sensitive pressure gauges were then designed and constructed, and thermometers were purchased to meet the requirements thus found. Further preliminary tests were afterwards made on each furnace in order to become familiar with its operation and to ascertain the best working conditions as well as the sizes and types of fuels adaptable. One of the gauges constructed, but not yet calibrated, is sensitive to a pressure of 1/1000th of an inch of water. Other gauges constructed read to 1/100th of an inch. A water meter has been installed and calibrated, and a recording thermometer also has been procured. The preliminary work is now so far advanced that systematic tests can be made at once in the coming year. The following outline shows the extent of the work done on each furnace. The short tests referred to are trial runs of six to ten hours in length.

R. W. King Hot Air Furnace.—This furnace is designed to burn slack domestic coal. Three short tests and two twenty-four hour tests have been made to determine the best method of firing, also one seventy-nine hour test, in addition to a number of trial runs carried out in these laboratories by the inventor of the furnace. The information gained was mainly used for designing air boxes, etc., as described above. Two new sets of grates have since been cast from patterns supplied by Mr. R. W. King. They will be tested shortly.

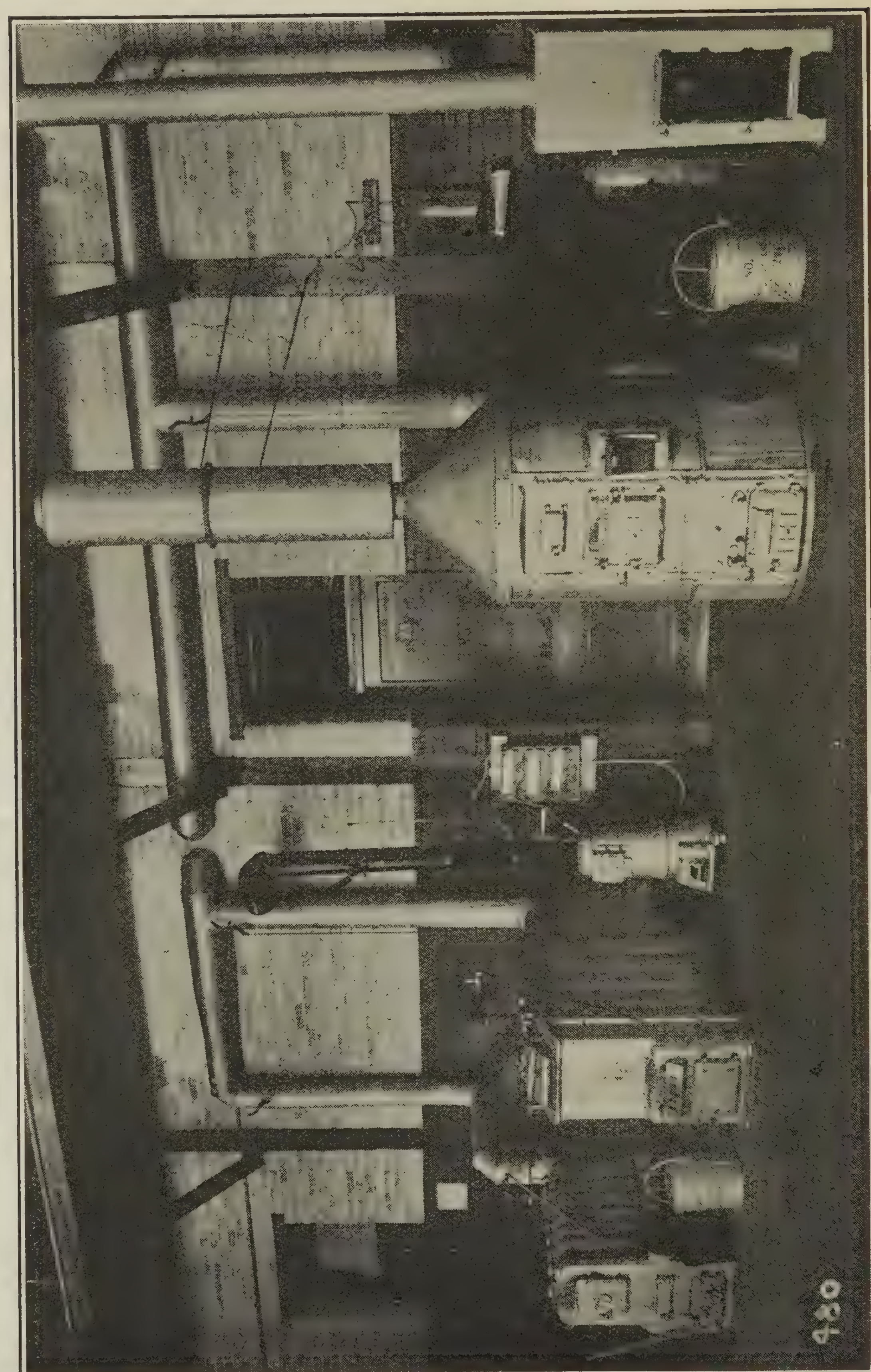


Fig. 11.—Domestic Heaters.

Sunshine Hot Air Furnace.—This is a standard type of hot air furnace. Two short tests only, on methods of firing, have so far been made on this furnace. A Pratt brick arch, made to fit, has been installed but not yet tested. It is designed to simplify the alternate method of firing.

Allan Hot Water Furnace.—This is a magazine furnace designed to burn high volatile, non-coking coals. Three short tests have been made, and one forty-eight hour test.

Gurney Hot Water Furnace.—This a standard type of rectangular furnace. It has a firebox large enough to enable the alternate method of firing to be used, and it can be made to burn slack coal. Two short tests were made to study the methods of firing, and one forty-eight hour test. In the latter test it was found that forty-five per cent. of the available heat was transmitted to the water. It is hoped materially to increase this efficiency.

Mogul Water Heater.—Eight short tests were made on this heater. Particular attention was given to the effect of draft control by means of a regulating damper and by a patented damper, or "fuel saver." Tests with and without a damper showed that an increase of as much a five could be made in the percentage efficiency by careful regulation of the damper.

Carbonization

A carbonizer intended for non-caking coals has been designed and constructed. Two photographs of this are shown in figures 12 and 13. The raw coal is fed in through the funnel at the top, and the carbonized material is withdrawn mechanically through a cooler on the right. The hot, tar-bearing gases are cooled and scrubbed by passing them through a pipe scrubbing system. The clean gas then passes through a pump and escapes through a gas meter. The tar and water condensed from the gas are collected in a sump box below the scrubber. The carbonizer is heated electrically, and the current required is measured by means of the ammeter and voltmeter shown. This apparatus was not completed in time for any tests in 1921.

Coal Purification

No systematic work on coal purification has yet been attempted, but Mr. A. E. Cameron, of the Mining Engineering Department, has made several coal washing tests on the coals received with Wilfley table, jig and classifier.

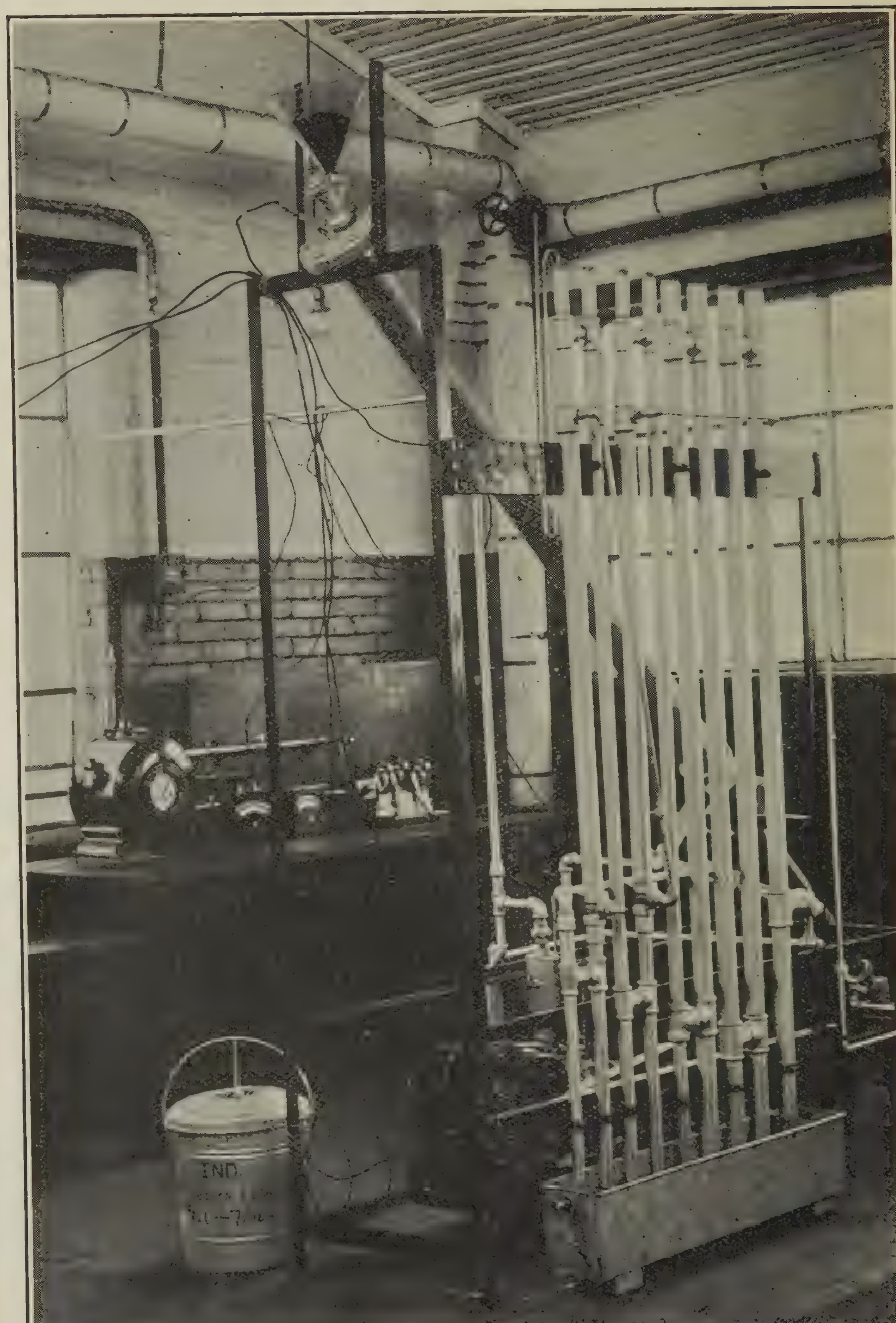


Fig. 12.—Lignite Carbonizer, General View.

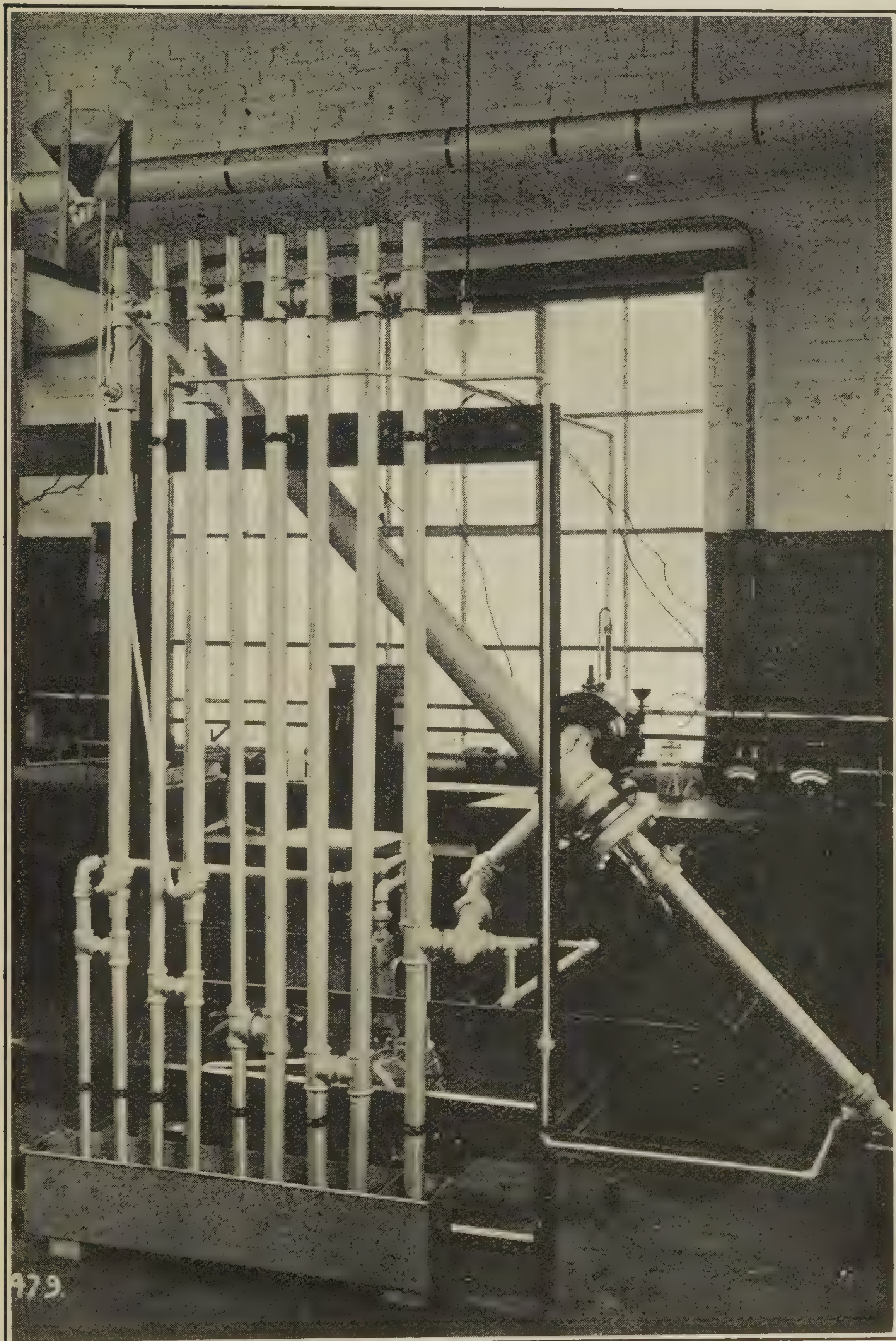


Fig. 13.—Lignite Carbonizer, Side View.

BOILER TRIALS

By Charles A. Robb

Professor of Mechanical Engineering
University of Alberta

Report of boiler trials conducted at Plant No. 2 of the University of Alberta at Edmonton.

Introduction

The boiler trials have been conducted at the request of the Scientific and Industrial Research Council of Alberta for the purpose of establishing the relative values of the different Alberta coals in the generation of steam.

It is to be noted that the furnaces on which the trials were carried out are specially constructed to burn the local coals, and for these both hand-fired and stoker-fired results are given.

The special arch of the stoker does not permit the use of bituminous coals, which are reported as for hand-firing only, and in this case the furnace was not so well adapted to the coal.

Preliminary runs were made to permit the staff to become familiar with the characteristics of the coal to be tested. The trials in all cases were of eight hours duration.

The water fed to the boiler was measured by means of a Cochrane V-notch meter and the coal was weighed on a Fairbanks platform scale.

The alternate method (A.S.M.E.) of conducting the trials was used throughout.

The order of treatment of the coals listed below is based on Bulletin No. 25 of the Mines Branch, Ottawa, "Analyses of Canadian Fuels."

Description of Boilers

The boilers are Babcock & Wilcox water tube. Heating surface, 2,197 square feet. Builder's rating, 220 H.P. The hand-fired unit has a grate area of 44 square feet, the furnace being a Dutch oven type with fixed grates. The chain grate stoker, which is special, has a grate area of 60 square feet and close links.

Acknowledgements

All the coals were obtained through the Research Council.

The analyses and determinations of the calorific value are the work of Mr. J. A. Kelso of the University.

Mr. H. A. McMillan, engineer in charge of Plant No. 2, maintained the boiler in proper working condition and assisted in carrying out the trials.

Messrs. R. T. Hollies and J. W. Lewis assisted.

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LIST OF ALBERTA COALS TESTED AT POWER PLANT NO. 2.

The coals have been numbered to facilitate tabulation of the boiler trials given in the folder.

(Abbreviations used: Bit.=Bituminous; R.O.M.=Run of Mine)

Coal No.	Test No.	Kind of Coal	Mined by	Area	Grade
1	B-16	Mountain Park	Mountain Park Coal Co., Mountain Park, Alta.	Mountain Park	Bit. R.O.M.
2	B-12	Cadomin	Cadomin Coal Co., Cadomin, Alta.	Mountain Park	Bit. Steam
3	B-15	Pocahontas	Jasper Park Collieries, Pocahontas, Alta.	Jasper Park	Bit. Steam
4	B-13	Mixture, 2 parts Pocahontas - 1 part Cadomin.			Bit. Steam
5	B-17	Blue Diamond	Blue Diamond Coal Co., Brule, Alta.	Jasper Park	Bit. R.O.M.
6	B-20	Foothills	Foothills Coal Co., Foothills, Alta.	Yellowhead Pass	Bit. R.O.M.
7	B- 9	Pembina	North American Collieries, Evansburg, Alta.	Pembina-Wabamun	R.O.M.
8	B-10	"	North American Collieries, Evansburg, Alta.	Pembina-Wabamun	R.O.M. Cracked fine
9	B-18 & B-19	Tofield	Dobell Coal Co., Tofield, Alta.	Tofield	Screened lump
10	B- 4	Humberstone	Humberstone Coal Co., Beverley, Alta.	Edmonton-Clover Bar	Nut
11	B- 5	"	Humberstone Coal Co., Beverley, Alta.	Edmonton-Clover Bar	Slack
12	B- 7 & B- 8	Twin City	Twin City Coal Co., Edmonton, Alta.	Edmonton-Clover Bar	R.O.M.

GEOLOGICAL RECONNAISANCE IN ALBERTA DURING 1921

BY JOHN A. ALLAN

INTRODUCTION

Considerable time was spent during the year in testing samples sent in for examination, and in supplying information to individuals, companies and industrial corporations on various phases of mineral resources and development in Alberta. In the office work the writer was ably assisted by Miss Vera V. Lee, M.Sc., graduate in geology, who spent part time in the employ of the Research Council. In the field a reconnaissance examination was made of the geological conditions in various districts, and all available data on reported occurrences of mineral deposits in other districts were investigated. Brief notes on each of these districts are given below.

The most important field investigation carried on during the summer was in the Drumheller district; but only a brief summary of the results of this work will be given here, as the detailed report with maps and sections is being published as the "Third Annual Report on the Mineral Resources of Alberta," (Report No. 4).

GEOLOGICAL WORK IN DRUMHELLER DISTRICT

The town of Drumheller is situated in the Red Deer valley, 185 miles south from Edmonton and 85 miles east-north-east from Calgary on the Canadian National Railway. About five miles downstream from Drumheller, at Rosedale, the Rosebud river enters from the south west. The Drumheller district includes the towns of Drumheller, Rosedale and Wayne, the latter being situated in the Rosebud valley, three miles from its mouth. As this is the most important domestic coal mining district in Alberta, it was decided that a detailed geological study should be made of the area. About three and a half months were spent in the field and an area about 15 miles long and 5 miles wide was mapped in detail. The field party consisted of five men: R. L. Rutherford, in charge; J. O. G. Sanderson, assistant geologist; A. D. MacGillivray, instrument man; F. D. Marleau and W. A. Lang, assistants.

The outcrops of all the more continuous coal seams, eleven in number, were mapped. Special attention was given to the vertical and lateral variations in the various coal seams, more particularly in those that are being mined. Much information on this point was obtained at the various mines through the courtesy of the mine owners and operators. As all the coal seams occur in the lower part of the Edmonton formation, the individual seams were given numbers, beginning with the Drumheller seam as No. 1, as this is

the lowest seam being mined. There is one small seam below No. 1, which has been called No. 0 seam. There are 13 mines working on No. 1 seam in the area mapped. No. 2 seam is worked in the Celtic and Sunshine mines. No. 5 is a very important seam, formerly known as the Newcastle, and is worked in 9 mines. No. 7 is a smaller seam and is worked in the Brooks mine. Above this there are three other seams exposed at certain points along the upper slopes of the Red Deer valley in this district.

The field mapping was carried out on the scale of 1 inch to 1,000 feet, and the published map is on the scale of 1 inch to 2,000 feet. This map, which accompanies Report No. 4, is published in six colors; the engraving and printing have been done in Edmonton. As the formations are lying nearly horizontal the outcrops of the coal seams indicate the character and topography of the country.

In addition to the geological map, the report is accompanied by profile sections, startigraphic columnar sections, sections of the coal seams worked at the various mines, and photographs illustrating the geology of the district. It is not necessary to give further details on this work in this brief summary.

Section Between Peace River and Hudson Hope

The first two weeks of July were spent in examining the geological section between Peace River and Hudson Hope. The object of this investigation was to examine the section which is so well exposed along Peace river, so that the formations along the western border of the province and south of Peace river might be correlated more accurately.

At Peace River, the valley ranges from 750 to 800 feet in depth. Good sections are exposed along the river and also along the Heart river which enters at Peace River. The slopes of the valley of Smoky river also show good exposures. The formations, determined by F. H. McLearn, and given in the Geological Survey Summary Report, 1918, Part C, are tabulated here in abbreviated form:

Upper Cretaceous	Montana	Wapiti Upper Smoky River	
	Colorado	Smoky River Dunvegan St. John	
Lower Cretaceous		Peace River Loon River	*or* Bullhead Mountain (on Upper Peace)

The writer left Peace River on July 1st, on board the "Ingenika," which runs between Peace River and Hudson Hope. Near the mouth of Heart river the Peace River sandstones outcrop from the waterline to an elevation of 200 feet. These rocks are overlain by 300 to 600 feet of yellowish sands and clays, largely of lacustrine origin. This formation probably corresponds in age to the Bullhead Mountain sandstones which are exposed further up the Peace.

The upper members in the Peace River sandstones are very distinctly cross-bedded, and in some places the weathered surface is incrusted with yellow sulphur.

The St. John shales consist chiefly of marine beds with occasional lenses of sandstone and rusty shales. These shales come to the waterline on the north side of the Peace opposite Smoky river. The shales, where exposed, tend to form fine textured black talus. The upper members in the St. John formation appear to be arenaceous.

The first exposure of the Dunvegan sandstone was noticed on the south bank of the Peace almost opposite the mouth of Griffin creek, and about 250 feet above waterline. The Dunvegan formation consists mainly of massive, cross-bedded, soft sandstones, inclosing many large, flat, nodular masses. The sandstone in many places weathers into castellated forms. A thin seam of lignite, less than 6 inches thick, was noticed in this formation. This formation also contains a rather prominent fossiliferous limestone bed, made up largely of fresh water shells. It would seem that the upper and lower contacts of the Dunvegan formation indicate gradation changes from marine to fresh water or brackish water conditions and back again to marine conditions.

A point about the mouth of Spirit and Burnt rivers from the south, and Little Burnt river from the north, represents about the last appearance of the St. John shale. The sides of the valley from this point upstream show the Dunvegan sandstones with numerous nodular bands. These nodular bands weather out into rather fantastic forms. This portion of the valley is in places not more than a mile and a half wide and is about 650 feet deep. The north side of the valley is almost void of timber of any kind, but the south side is heavily wooded right down to the waterline, spruce, poplar and cotton-wood predominating. The spruce is more abundant where the sandstones outcrop.

Dunvegan is situated in section 7, township 80, range 4, west of the 6th meridian. There is a ferry at this point, and the elevation of water-level is given as 1,113 feet above sea level. From this ferry a good trail leads southwest to Spirit River. Upstream from Dunvegan, about the mouth of Hamelin creek, the Smoky River

formation appears to cap the upper slopes of the valley. West of Hamelin creek, there is a decided rise in the measures, and the Dunvegan formation occurs at the waterline. The sandstone continues to rise slowly towards the north to the mouth of Montagneuse river. In section 31, township 82, range 6, the St. John shales occur at the waterline. At the mouth of Montagneuse river, about 300 feet of St. John shales occur above water-level, and the overlying Dunvegan formation apparently extends almost to the top of the valley. Continuing westward, the Dunvegan sandstones occur again at waterline near the mouth of the Clearwater river in range 11, but within three miles upstream the overlying St. John shales reappear. A very prominent rampart of sandstone 100 to 125 feet high rises abruptly from the waterline and extends for several miles in range 12. At the mouth of Pouce Coupe river, these sandstones come right down to the waterlevel. Pouce Coupe landing, or Rolla landing, is situated about three miles upstream from the mouth of Pouce Coupe river. At this point the St. John shales are exposed for about 100 feet above the waterline. This indicates that from this point downstream there is a marked dip towards the east. Continuing upstream, the St. John shales rise rapidly towards the west. This rise, which averages from 50 to 75 feet per mile, continues at least as far as the mouth of North Pine river in township 82, range 16. The shales are very black in color and contain thin, hard, calcareous bands and, sometimes, well-rounded nodules. The sides of the valley are badly slumped and mud avalanches are common. At Fort St. John a dredge was being erected by the Peace River Dredging Company for the recovery of gold from the gravels, but no reports have been received as to the extent of operations during the year. A small hand machine of the Roberts Rotary Alluvial Washer type was being operated by Messrs. Booth and Brown close to Fort St. John.

Upstream from Fort St. John the valley ranges from 500 to 900 feet in depth. Exposures are not so common, but the St. John shales are believed to be responsible for the character of the valley slopes. About 8 miles above the mouth of Halfway river two deposits of calcareous tufa were noted from the boat. This carbonate of lime has been deposited from springs.

About two miles above Farrel creek, in township 82, range 24, the formations rise rapidly to the west. This represents the eastern limit of an anticline, which McLearn calls the Gates anticline. The dip at this point is about 180 feet to the mile. In section 10, township 82, range 25, the beds flatten rapidly so that the structure seems to be monoclinal rather than anticlinal. The "Gates" are located two to four miles downstream from Hudson Hope, and consist of prominent cliffs, both on the mainland and on the various islands, of a sandstone member of the St. John formation, 50 to 80 feet thick. These beds are best exposed in the canyon, the lower mouth of which lies about one mile west of Hudson Hope. At the

upper end of this canyon, in the Bullhead Mountain formation, there are several coal seams exposed. The quality of this coal is very high, and has been classed as bordering on anthracite. If these deposits are opened up, it will be necessary to transport the coal overland, as the character of the canyon makes it impossible to utilize the waterway.

LIMONITE DEPOSIT

On various occasions samples of limonite ore, a hydrated form of iron oxide, have been exhibited in Edmonton from a district on the upper Peace river, towards the head of the Halfway river. The extent of this deposit of bog ore will be determined by a private company during the ensuing summer.

A number of specimens, said to represent the tenor of the deposit, were brought to the writer and were analysed by J. A. Kelso, Director of the Industrial Laboratories, University of Alberta. The analyses of these specimens are as follows:

	No. 1 Per cent	No. 2 Per cent	No. 3 Per cent	No. 4 Per cent
Iron oxide	69.6	54.8	67.4	72.6
Metallic iron	48.7	38.3	47.2	50.8
Sulphur	0.04	trace	0.06	0.06
Phosphorus	0.05	trace	0.04	0.03

HEMATITE IRON

In October, 1921, considerable publicity was given to the reported discovery of iron on the north shore of lake Athabaska by Messrs. E. A. Butterfield and Norman C. Butterfield. The location of this reported discovery is on the north shore of lake Athabaska in the vicinity of Black bay, and not far distant from Crackingstone point.

This is really not a discovery of iron, as the presence of iron ore in the rocks of this district has been known since the district was examined by J. B. Tyrrell in 1893. His report on the district appears in the Annual Report of the Geological Survey of Canada, Vol. VIII., page 61 D, 1895.

During the summers of 1914 and 1916, F. J. Alcock, of the Geological Survey, investigated the north shore of lake Athabaska, and his reports on the occurrence of iron are given in the summary reports of the Geological Survey for those years. The published statements of members of the Geological Survey are to the effect that the quantity of iron is extremely small, although the quality is good. Alcock is of the opinion that the quantity would not warrant mining development.

Messrs. E. A. and N. C. Butterfield, during the summer of 1921, located several claims on showings of iron, in a formation which they claim extends under the surface of the lake. A number of hand specimens were brought out by these prospectors, but none of these specimens could be taken as representing the average tenor of the ore. All of the specimens were taken from the surface, and several of them still had the moss attached. The specimens examined by the writer were found to be hematite ore, two types being represented. One type is jaspelite, which is a mixture of jasper and hematite, and is not unlike some of the jaspelite found in the lake Superior district. The other type represented in these specimens is a micaceous hematite, with which is associated a quartzite gangue. These specimens, although excellent in quality, do not give one any idea as to the quantity. Two of the hand specimens which were picked from the lot by the writer were analysed by J. A. Kelso at the University of Alberta, and the results are as follows:

	No. 1 Per cent	No. 2 Per cent
Silica	21.4	20.9
Iron Oxide	70.6	70.8
Phosphorus	0.03	0.03
Sulphur	0.06	0.08
Equivalent in Iron of above Iron Oxide	49.4	49.6

This iron locality is on that portion of the lake which lies in Saskatchewan, but should a workable deposit be found in that area, it would have to be transported from the west end of the lake, which is in Alberta. It is quite possible some portion of the iron formation which has been previously overlooked may prove to be extensive enough to warrant mining development. This observation cannot be substantiated until more extensive field investigations have been carried out. It is the intention of the Research Council of Alberta to send a party into this field during 1922 to investigate the iron and other mineral resources.

Aluminium Sulphate

During the year several samples of aluminium sulphate, sent in from the Peace river country, have been examined in the laboratory. In some cases the exact locality from which the specimens were taken could not be ascertained, but one specimen which was collected from the banks of the Smoky river near its mouth gave the following analysis when tested at the University of Alberta:

Alumina	12.90 per cent
Oxide of Iron	0.70
Lime	nil
Magnesia	0.02
Sulphuric anhydride	39.92
Moisture and water of crystallization	45.41
Insoluble matter	0.68
Potash	nil
Soda	nil

Other samples of incrusted salts from the district north of Edmonton proved to contain a high percentage of aluminium and iron sulphates. No further details can be given on these occurrences at the present time.

GLAUBER'S SALT DEPOSIT

In July the writer visited a deposit of Glauber's salt (sodium sulphate) which occurs about 100 miles east of Edmonton, and six miles southwest of the town of Minburn. This deposit is situated in the south half of section 12, township 50, range 11, west of the 4th meridian, and covers about 25 acres. The deposit forms the floor of two irregularly rounded lakes. The smaller one lies about five feet above the level of the larger one. These lakes are very shallow, and sometimes quite dry. When visited, they were both nearly full of brine, but an incrustation of sodium sulphate was quite apparent. The salt comes from brine springs, the strongest one observed being situated on the north side of the smaller lake. The greatest thickness of the pure mineral noticed anywhere was only four inches, but it was stated that when the lake was dry a deposit of from ten to fourteen inches was found in the centre of the basin.

Several tons of Glauber's salt excavated from this deposit are stacked on the shore of the lake. This material, when examined, proved to be remarkably nearly pure, as analyses made at the University of Alberta gave the following results:

	Per cent
Sodium sulphate and water of crystallization	97.50
Insoluble	0.78
Calcium sulphate	0.36
Magnesium sulphate	0.84
Potassium sulphate	0.20
Sodium chloride	0.32

Oil Possibilities in Irma District

A few days were spent in the vicinity of Irma, 110 miles southeast of Edmonton, examining the geological structure along the Battle river. Between Irma and Fabyan there has been defined a prominent terrace structure which apparently is more or less continuous to the northwest beyond Birch lake. This structure has also been traced to the southeast as far as Misty hills, south of Monitor. The northern part of the structure is known to contain large quantities of gas, as proven by a number of wells put down in the district northeast of Viking, and also on Grattan coulee, south of Irma. The Grattan well has been capped for a few years, and when visited showed a gas pressure of 695 pounds on the gauge attached to the top of the casing.

The Imperial Oil Company began drilling a well for petroleum at Fabyan, east of Irma, in section 18, township 45, range 7, in December, 1921, and by the middle of January they had reached a depth of about 1,500 feet. This is the only well that is being drilled this winter in Alberta. The geological structure through this part of Alberta is very favorable for oil accumulation, and, on account of its accessibility, the district undoubtedly will be thoroughly tested in the near future.

Clay

A short visit was made to Redcliffe to investigate certain clay deposits that were being utilized by the Redcliffe Coal and Brick Company. One day also was spent in the vicinity of Lethbridge, looking into occurrences of a clay which had been tested in the laboratory during the previous winter. This latter prospect, however, proved to be too small, and much too irregular in composition, to warrant further attention.

Athabasca River Section

Late in the season two days were spent in examining the structure southwest from Edson along the Coal Branch, and also along the Athabaska river into the mountains. The object of this brief examination was to lay out plans for more extensive field work during the field season of 1922. A few days were also spent on the foothill geology, southwest from Calgary.

Reported Platinum Discovery

Considerable excitement arose last October over a report that rich platinum values had been obtained from gravels along Smoky river below the mouth of Little Smoky. Several claims were staked, and more than a score of samples were assayed by J. A. Kelso and A. E. Cameron for platinum, but not a single trace of this metal

could be detected. The writer and Mr. Kelso also examined several samples for tungsten, but were not able to detect even a trace of the same. The clays sent in contain numerous minute marcasite nodules.

An investigation by the writer traced this excitement to its source. A chemist of the Customs Department, Ottawa, analysed a sample of wire filament from a tungsten electric light bulb for a party at Grande Prairie, and prepared a report in the usual way. A copy of this report was obtained, apparently, by some unscrupulous party, who exhibited it as an analysis of a mineral product of the district. This is a good example of the unfair methods still made use of to boom mineral claims. Such methods have the result that much money is uselessly wasted on false reports of mineral discoveries.

THE BITUMINOUS SAND AND ITS COMMERCIAL DEVELOPMENT

By K. A. CLARK

Preface

The Department of Industrial Research is working on the problems connected with the development of the Alberta bituminous sand deposit. The work has not been advanced to a stage which warrants an announcement of results. It is believed, however, that a useful purpose can be served by publishing a discussion of the known facts regarding the bituminous deposit and the materials it contains. Such a discussion will indicate the views which the Department holds on the subject of bituminous sand development and which are governing the course of its investigations. It will be an aid to others who are also studying the bituminous sands. Finally, it will help those who have a general interest in the matter to understand the bituminous sand problem.

The general facts, gathered together from the scattered sources of information in which they may be found, are as follows:

The deposit, though of enormous extent, is not all readily available for development purposes. It is only those portions of it, in fact, which are exposed in the sides of the river valleys that can be excavated without encountering overburdens so excessive in thickness as to make the cost of development prohibitive. The valley outcrops, however, can provide ample material to satisfy all demands of the immediate future.

Good grades of bituminous sand, obtainable from the valley outcrops, contain from fifteen to eighteen per cent. of bitumen. The balance of the material is sand and silt. The sand varies considerably in character, but, generally speaking, it consists of fine to very fine grains of quartz.

The bitumen contained in the bituminous sand, excavated from the outcrops, is a black, very viscous, asphaltic liquid. Contrary to common belief, this bitumen is not petroleum. It is what remains, at present, of the petroleum which saturated the bed of sand an unknown number of thousands of years ago. Whatever may be its early history, the bitumen now present in the exposed bituminous sand resembles the residue left by an asphaltic petroleum after most of the gasoline, kersosene and light oil constituents, available by ordinary refining operations, have been removed from it.

The bitumen contained in the bituminous sand constitutes a direct source from which to prepare asphaltic products such as those used for road construction purposes. This bitumen does *not* constitute a direct source from which to obtain satisfactory yields of gasoline, kersosene and lubricating oils by operations now practised in the petroleum industry.

Gasoline, kerosene and lubricating oils may be manufactured from the bitumen contained in the bituminous sand by indirect means involving chemical decompositions and transformations in the bitumen. Such a means is provided by the process of destructive distillation. When this process is applied to the bituminous sand very serious manufacturing losses are encountered. Available evidence indicates that in arriving at marketable gasoline, kerosene and lubricants by destructive distillation, followed by the present day methods of refining, approximately one-half of the bitumen is converted into products of little or no value.

The author draws the following conclusions, pertinent to the question of how the deposit may be developed, from the facts which have been enumerated.

The deposit lies so far from centres of population that the transporting of crude bituminous sand does not appear as a likely way in which a substantial development of the deposit will take place.

The development of the bituminous sand deposit depends upon the discovery of a suitable method of separating the bitumen from the sand. The bitumen, free from sand, should be of sufficient value to stand the cost of transportation.

A suitable separation process will fulfill several conditions: it will effect the separation of the bituminous sand cheaply; it will not materially alter the nature of the bitumen; and it will leave the way unobstructed for the utilization of the bitumen in any profitable manner now known or which may become known in the future.

The conversion of the bitumen of the bituminous sand into gasoline, kerosene and lubricating oils by means of the operation of destructive distillation may prove a profitable method of developing the deposit. The method will have still better chances of success if applied to the bitumen, cheaply separated from the sand, rather than to the crude bituminous sand.

The market for products obtainable from the bituminous sand would be greatly widened, and the opportunity for the establishment of a bituminous sand industry in the near future would be enhanced, if a means could be developed for employing the asphaltic bitumen in the construction of a serviceable type of improved road suitable to the rural needs of the prairie provinces.

INTRODUCTION

The bituminous sand deposits of the province still remain undeveloped. This condition is not due to any abatement of interest on the part of the public; for every Albertan is still alert with interest whenever the topic of bituminous sands is mentioned. It is not due to an unfavorable attitude on the part of the provincial government; for the legislature stands ready to encourage any plan which give promise of turning this northern resource of the province into a revenue producing asset. Finally, it is not due to lack of effort on the part of those who possess technical ability and ingenuity; for announcements of new plans for the development of the bituminous area make frequent appearances in the press. The reason is more deep-seated.

The reason for lack of progress in the development of the bituminous sand is due to practical difficulties arising from the nature of the material, coupled with the remoteness of its place of occurrence. The latter circumstance prevents its direct utilization in the natural form. If the deposits were close to centres of population, quite large quantities could be used to advantage. There is in Edmonton today a stretch of successful bituminous pavement, built of the bituminous sand some years ago as an experiment and demonstration. But, unfortunately, the great excess of sand which must be shipped in order to obtain the desired bitumen* where it is required makes the bitumen too expensive for the purposes it can serve. The successful development of the deposits requires that the sand be left behind in the north and only the bituminous constituent be transported. This requirement, in turn, necessitates the discovery of a process which will separate the bituminous sand, as mined at the deposit, into sand and the contained bitumen. The process must perform this operation at low cost. In addition, it must not cause undesirable transformations in the nature of the bitumen, which will impair its value for the purposes to which it is best suited. It is the lack of such a process which is standing in the way of progress.

*The terms "bitumen" and "bituminous material" will make frequent appearances throughout this article. A "bitumen" is defined by the American Society for Testing Materials as "a mixture of native or pyrogenous hydrocarbons and their non-metallic derivatives, which may be gases, liquids, viscous liquids or solids, and which are soluble in carbon disulphide." Such substances as petroleums and asphalts, produced by the agencies of Nature, are mixtures of hydrocarbons and are soluble in carbon disulphide. They are bitumens. The tars produced in gas plants and in coking ovens are mixtures of hydrocarbons formed by an artificial heat treatment of coal. They also are soluble in carbon disulphide and are classed as bitumens. The term "bituminous material" is used in this article to mean a material from which bitumen can be obtained. Bitumen may be extracted from the bituminous sands by the solvent action of carbon disulphide. The bituminous sand is a bituminous material. Little, if anything, can be extracted by carbon disulphide from coal. However, when coal is destructively distilled, it yields a tarry distillate which is a bitumen. Coal is consequently also regarded as a bituminous material. For the same reason oil shales and pyrobitumens are in the bituminous materials class.

The successful solution of the problems of the separation of the bituminous sand into its component parts of bitumen and sand, and of the economic utilization of the recovered bitumen, will, of necessity, have an intimate relation to the properties and characteristics of the original material. It will also bear a relation to the properties and characteristics of other bituminous materials, to knowledge and information which has been accumulated in the study of bitumens in general, and to the experience of the industrial world in manufacturing useful bituminous commodities. An examination of the characteristics of the Alberta bituminous sand in its relation to those of other bituminous materials which are better known and understood is consequently indicated as a logical step in the search for the solution of the development problem as well as in an inquiry after the reasons for lack of progress.

THE BITUMINOUS SAND

An enumeration of its characteristics and the general facts regarding its occurrences forms the natural preface to any discussion of the bituminous sand. The bituminous sand, as the name implies, is composed of a mixture of sand and bitumen. The mineral constituent consists of a fine quartz sand and a very fine silt. The bitumen is present in the form of a layer enveloping each mineral particle. It is a dark brown to black, very viscous, sticky liquid. The bituminous sand as a whole is brownish to black in appearance. The fresh material is fairly soft; it can be molded by the pressure of the hand. It has a decided asphaltic odor. Good samples of bituminous sand contain from fifteen to eighteen per cent. by weight of bitumen.

The bituminous sand occurs in a deposit underlying thousands of square miles of the northern part of Alberta. The bituminized area to which attention is most directed centres about McMurray, at the junction of the Clearwater and Athabaska Rivers. The area is now easily reached by a journey of about 300 miles over the Alberta and Great Waterways Railway, north and somewhat east from Edmonton. The bituminous bed lies on a floor of limestone. It has a thickness, at McMurray, of about one hundred and fifty feet. It is covered by an overburden varying from a few feet to two hundred feet in thickness. The nature of the overburden varies from unconsolidated material to a solid shale and sandstone formation.

Only a small portion of the bituminous sand deposit has any immediate practical significance. The excessive overburden of the greater part of the area underlain by the material makes the deposit inaccessible. The Athabaska River and some of its tributaries, however, have penetrated the overlying strata of sandstone and shale as well as the bituminous bed, and have exposed the bituminous sand in prominent cliffs along the valleys. Some low-lying areas have also been formed where the bituminous sand may be

reached under a moderate overburden. The existence of the bituminized bed is revealed by these valley exposures. Our knowledge of the material is derived from an examination of the outcrops. What variations there may be in the nature of the bituminous sand if one could trace it back from the outcrops into the main body of the deposits are yet unknown. Discovery of such variations may have an important bearing on development methods of the future. For the present, however, it seems altogether probable that excavation of the deposit must be confined to the valleys where the bituminous sand can be fairly easily reached.

CLASSIFICATION OF BITUMINOUS MATERIALS

With this brief account of the material in which we are primarily interested, we can now proceed to seek its relation to bituminous materials in general. Helpful suggestions should result from the establishment of this relationship.

Bituminous materials fall naturally into two main groups. One contains those substances which have come into being through the agencies which have caused the formation of coal; the other contains those which are related to the petroleums. Coal, undoubtedly, has been formed by nature from organic matter of vegetable origin. Petroleum, very likely, is also organic in origin, derived from both vegetable and animal matter. But this very distinct difference has occurred between the two classes of bituminous material: all substances of the nature of coal are solids which yield bitumens only on being subjected to a severe treatment; while the majority of substances belonging to the petroleum group are liquids and are naturally bitumens. Some members of the petroleum family are very viscous liquids. Some are even semi-solid. A few have been so altered by natural agencies that they are no longer true bitumens. They have, consequently, been given the name of pyrobitumens. Figure 14 shows the interrelationships in the two groups of bituminous materials.

The coal group of bituminous materials is of interest to us because it includes the oil shales. The principal type of procedure along which the exploitation of the Alberta bituminous sand is being sought is that which is used in the treatment of oil shales. This procedure is the heat treatment called destructive distillation. The term "oil shale" is incorrect and misleading. This type of material contains no oil, as such. The bituminous constituents in the shales are solids which can be made to yield true bitumens only by strong heat treatment. Most oil shales have an origin similar to that of coal. Some, however, have been derived from asphaltic petroleums, the original petroleum having gone through natural modifications until it has acquired the nature of a pyrobitumen. There is no analogy between the oil shales and the bituminous sands which would suggest that exploitation methods applicable to the former should be applied to the latter. The oil shales become a source of bitumen only when subjected to heat; the bituminous sand in its natural form already contains bitumen.

Fig. 14.—DIAGRAMMATIC CLASSIFICATION OF BITUMINOUS MATERIALS

CELLULOSE OR WOODY FIBRE DERIVATIVES

Vegetable Growth in Bogs, Swamps, Etc.

Peat
Lignite
Bituminous Coal
Anthracite Coal
(Coal types. Essentially bituminous matter.)

Lignite Shales
Coal Shales
("Oil Shale" types. Mineral matter impregnated with bituminous constituents.)

PETROLEUM DERIVATIVES

Petroleum

Non-Asphaltic or Paraffin Petroleums
Mineral Waxes

Mixed-Base and Asphaltic Petroleums

Bituminous Sand Rock Asphalts
Impure Asphaltites
Asphaltic Pyro-bituminous Shales
(Mineral matter impregnated with bitumen).

Asphalts
Asphaltites
Asphaltic Pyro-bitumens
(Bitumens essentially free of mineral matter).

The general position of the Alberta bituminous sand in the classification of bituminous materials can readily be determined. It falls in the group of materials connected with the petroleums. This follows from the fact that it contains a bitumen as a natural constituent. The petroleum group is divided into two sub-groups, the parraffin or non-asphaltic petroleums, and the asphaltic petroleums. The paraffin petroleums are light, mobile liquids. When exposed to the transforming agencies of nature, they give rise to mineral waxes. The asphaltic petroleums, on the other hand, when exposed to similar agencies, give rise to an array of viscous, sticky liquids and semi-solids. The semi-solids are commonly termed native asphalts. The bitumen of the Alberta bituminous sand is a viscous liquid, with stickiness as its most noticeable characteristic. These properties, along with association with a large amount of mineral matter, indicate that the Alberta product has its place in the classification near the rock asphalts. The asphaltites are solids at ordinary temperatures. They represent a more advanced stage of transformation of asphaltic petroleums than do the bituminous sand and the rock asphalts.

The Relationship of the Bituminous Sand Bitumen to the Petroleums and the native Asphalts

General considerations point toward the conclusion that the Alberta bituminous sand contains as its bituminous constituent a bitumen derived from asphaltic petroleum, which has approached by natural transformations the stage of an asphalt. More detailed examinations lend support to the same conclusion. One such examination will be considered. It follows from a consideration of the refining processes to which petroleums are submitted, and from a comparison of the products which the process produces.

The refining of a petroleum consists essentially of distillation operations which fractionate the petroleum into useful subproducts. As the petroleum is boiled in the still, vapors pass out and the boiling point of what remains behind rises. The residue in the still becomes thicker and heavier until a point is reached where no useful purpose is served by carrying the distillation further. This residue, when cooled, has the consistency of a semi-solid. In some cases it is a waste product, but in other cases it can be put to some valuable use. The vapors distilling over are condensed into fractions of increasing boiling point and gravity, and further refined to be used as gasoline, burning oils, and lubricants. The further refining consists primarily of redistillation. However, the products are also treated with concentrated sulphuric acid to remove undesirable constituents which give the products a bad odor and poor color and which resinfy on storage.

An interesting basis for the comparison of petroleums is provided by constructing diagrams to show the relative proportions of distillation products and semi-solid residues obtained by distillation of the various types of petroleums. The comparison can be extended to show, in addition, the relation of the bitumen of the Alberta bituminous sand and of the well known native asphalts to the petroleums, as well as to one another. Two classes of petrol-asphaltic petroleums and the asphaltic petroleums. A third class, eums have already been mentioned, namely, the paraffin or non-intermediate between these two, is generally recognized and is called the semi-asphaltic petroleums. A reason for this division of petroleums, as well as some insight into the transformations of asphaltic petroleums which result in the formation of products such as the Alberta bituminous sand bitumen and native asphalts, will follow from the method of comparison.

The distillation products of petroleum may be considered to contain three types of constituents. There is a certain proportion of resinous substances which is held in solution but which can be removed by filtration through fullers' earth. There are also constituents present which can be dissolved and removed from the main distillation products by treatment with concentrated sulphuric

acid. The third type of constituent is composed of the remaining main part of the distillation products which is indifferent to the action of sulphuric acid. The diagram (Fig. 15) shows the proportional division of the distillation products of petroleums into these three types of constituents.

COMPARISON OF BITUMINOUS SAND BITUMEN WITH PETROLEUM AND TRINIDAD ASPHALT

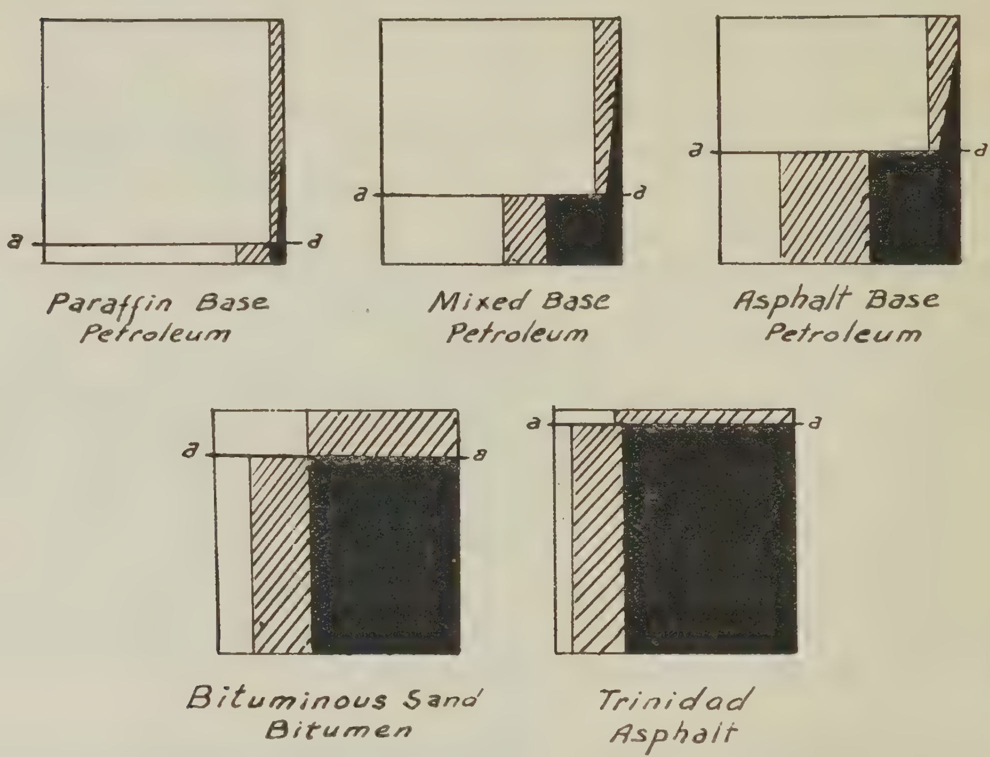

Fig. 15.—Comparison of Tar Sand Bitumen with Petroleums and Trinidad Asphalt.

Areas above lines **a—a** represent the distillates obtained by fractional distillation of petroleum. For the Bituminous Sand Bitumen and Trinidad Asphalt, line **a—a** was located by means of the volatilization loss at 250°C. for four hours.

Areas below lines **a—a** represent the semi-solid residue left after fractional distillation of petroleums or volatilization test on asphalts.

Unshaded areas represent hydrocarbons which fail to dissolve in concentrated sulphuric acid.

Shaded areas represent hydrocarbons which are removed by treatment with concentrated sulphuric acid.

Black areas represent hydrocarbons which fail to dissolve in 88°Be. naphtha; or which, if dissolved, can be removed from the solution by filtration through fuller's earth.

(The diagrams for petroleum are taken from "Bituminous Materials" by Prevost Hubbard in American Highway Engineer's Handbook. The diagrams for Bituminous Sand Bitumen and Trinidad Asphalt have been constructed from available data).

The semi-solid residues, left in the still after the commercial distillation of petroleums has been completed, can also be divided into several types of constituents. An oil derived from petroleum is, as a rule, a perfect solvent for all petroleums or petroleum pro-

ducts. However, the light, low-boiling napthas obtained from paraffin petroleums fail to dissolve some of the constituents of such bitumens as the semi-solid petroleum residues, the bituminous sand bitumen, and the native asphalts. The part which thus fails to dissolve is considered to be the constituent which imparts the asphaltic nature to the product in which it is present. With an "asphaltic nature" one associates the stickiness and binding qualities of what are regarded as asphaltic materials. The degree of insolubility of petroleum products in a standard, low-boiling naptha is used, in practice, as a gauge of the degree in which such products are to be considered asphaltic. The portions of the diagrams representing the semi-solid residues are divided into three sub-areas. One indicates the proportion of the semi-solid which fails to dissolve in the standard, low-boiling naptha. The remaining two areas divide the balance of the semi-solid residue into a portion which is dissolved by concentrated sulphuric acid and into another which is indifferent to this reagent.

The division of the diagrams corresponding to the bituminous sand bitumen and the Trinidad asphalt requires some explanation. The Alberta bitumen cannot be distilled in a way comparable to the distillation of a petroleum. If the attempt is made, chemical decomposition, instead of distillation, takes place. If, however, the bitumen is held for some hours at a quite high temperature, a portion of it volatilizes, and the residue, on cooling, is found to have changed from a viscous liquid to a semi-solid. The loss by volatilization for four hours at 400°F. has been used in the case of the bituminous sand bitumen and the Trinidad asphalt to determine the partition between distillates and semi-solid residue.

The diagrams show strikingly the characteristics of the three types of petroleums and the relationship of the bituminous sand bitumen and the native asphalts to the asphaltic petroleums and to one another. As one passes from the paraffin petroleums through the mixed-base to the asphaltic petroleums, the proportion of distillation products decreases, while the residue increases; the distillates show increasing content of constituents removed by concentrated sulphuric acid; and the residue becomes more and more asphaltic in nature. As for the Alberta bitumen, it is seen to resemble the residue left after an asphaltic petroleum has been distilled. It also resembles the native asphalts, of which Trinidad asphalt is a well known example.

Separation Processes

Now that the facts concerning the Alberta bituminous sand and its contained bitumen bearing most directly on the problem of development have been discussed, we are in a position to give intelligent consideration to some possible schemes of development. We

have noted that the bituminous sand contains bitumen as a natural constituent. This fact sharply differentiates the bituminous sand from the oil shales. Oil shales must be given severe heat treatment in some form of retort in order to produce bitumen from them; while the bituminous sand yields bitumen by applying to it any procedure which is capable of separating a mechanical mixture of sand and bitumen. The bitumen of the bituminous sand is asphaltic. It resembles closely the residue left after the distillation products have been removed from an asphaltic petroleum. It also resembles the well known native asphalts. The bituminous sand occurs in an unsettled region of northern Alberta, three hundred miles from the nearest centre of population. An adequate scheme of development must give these facts proper consideration.

Two obvious requirements must be satisfied by any plan of exploitation which is to be regarded as promising success: it must provide for an economical separation of the bituminous sand at the deposit into bitumen and sand; and it must look toward the utilization of the separated bitumen in the ways to which the present state of technical knowledge indicates that it is by nature adaptable. The bituminous sand deposit lies three hundred miles from the nearest centre of population. Five-sixths of its weight consist of worthless sand. Freight rates will soon outbalance any value the bituminous sand may have as a crude material. The separated bitumen, however, should possess a value which will withstand the cost of transportation. The bitumen of the bituminous sand is an asphalt. The commercial outlet for it will consequently be for purposes for which the world's output of asphalts is used. Any scheme of separation of the bituminous sands which will result in an alteration of the nature of the contained bitumen so that it will no longer be a good asphalt will most likely find itself so entangled in additional problems that it will have small chance of emerging with success.

Separation of the bituminous sand by the use of a solvent for the bitumen seems an obvious means of solving the problem. This method is employed in the daily routine of all laboratories engaged in the examination of bituminous materials. A sample of the mixture of sand and asphalt going into the construction of an asphalt pavement, for instance, is treated with carbon disulphide. The asphalt dissolves in the solvent and the sand is left behind. The solvent is evaporated and the bitumen obtained in the form in which it was present in the mixture. A commercial application of the method, however, presents serious difficulties and disadvantages. It is not easy to find a cheap, yet satisfactory, solvent. The prevention of solvent losses as well as the recovery of the solvent from the solution containing the bitumen also introduce expensive complications. The method appears to belong to the category of processes which are theoretically sound but which are difficult to put into successful practice.

Separation of the bituminous sand by destructive distillation is the plan which seems to be receiving the greatest amount of attention. The reason for the popularity of this method is not entirely apparent. It is true that destructive distillation is a quite old and well known process. It has been applied for many years in the treatment of coals to produce coke, tar and gas. It is also the method employed to produce bitumen from the oil shales. There is, however, no similarity between the bituminous sand and coals or oil shales which would indicate that the same type of procedure should be followed in the exploitation of these classes of materials. The bituminous sand is a mechanical mixture of an asphalt and mineral matter. No industrial process for the preparation of an asphalt for economic use submits the asphalt to destructive distillation. Such treatment spoils it for all purposes for which asphalt is considered to be useful. The destructive distillation of the bituminous sand does accomplish the production of a supply of bitumen free of mineral matter. But whether the bitumen so obtained can be commercially utilized is open to question.

The favor enjoyed by the scheme of destructive distillation of the bituminous sand is probably due mostly to the fact that the procedure leads to the production of gasoline, burning oils and lubricants. The manufacture of these commodities from petroleum is one of the most lucrative businesses in which the industrial world has engaged. Any procedure which will produce these valuable products from the bituminous sands would consequently appear to be well directed. If this is true, one naturally wonders why other asphalts, free from association with sand, have not been utilized in the manufacture of gasoline and the other related products. Unsolved difficulties obstruct the way. The production of the common petroleum products from asphaltic bitumens is still in the realm of experimentation.

Petroleum is a natural source of such products as gasoline, illuminating oils and lubricants. These products are directly obtained by distilling the petroleum and fractionally condensing the petroleum vapors. No profound chemical changes are involved. One can gain a fairly accurate conception of the process if he considers that the crude petroleum is a mixture of gasoline, kerosene, lubricating oils, etc., and that the distillation process simply separates the petroleum into these component parts. Purification of the products is accomplished simply and without too serious refinement loss by treatment with sulphuric acid. The petroleum lends itself naturally to the manufacture of the products in question.

An asphaltic bitumen, such as the bitumen present in the bituminous sand, is not a natural source of gasoline, illuminating oils and lubricants. It has already been shown that such a bitumen resembles what is left of an asphaltic petroleum when all these products have been removed. How, then, can it be expected to be a source from which to obtain them?

When the bituminous sand is destructively distilled a profound change is wrought in the chemical nature of the bitumen. A variety of products is formed: a portion of the bitumen is reduced to coke; another portion is converted to gas; while the balance is vaporized and may be condensed to an oil differing radically in nature from the original bitumen. The part of the bitumen converted to coke remains with the sand and is entirely lost. The gas which is formed can be burned to supply part of the heat needed for firing the retort. The oil distillate, only, remains available for manufacture into saleable products.

The crude oil distillate from the destructive distillation of the bituminous sand is comparable to crude petroleum. It, also, may be regarded as a mixture of gasoline, kerosene, lubricating oils, etc. It may be separated into these products by distillation, leaving behind a quantity of pitchy residue. These products, also, can be refined by treatment with sulphuric acid. But at this point there enters an unfortunate difference. The products obtained from petroleums can be refined without sustaining excessive refinery losses; whilst the products from the destructive distillation of bituminous sand lose about one-third of their volume in the sulphuric acid treatment. It must also be said that the gasoline and oils finally obtained are not equal, at least in the matter of color and odor, to the similar oils produced from petroleums.

The above facts are shown graphically in the following diagram. The data on which this is based are given below.

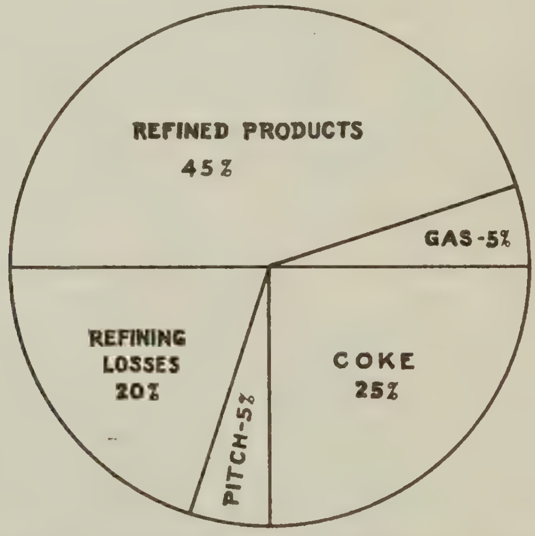

Fig. 16.—Products Obtained by the Destructive Distillation and Refining of the Bitumen from the Bituminous Sand.

Ells* found that the bituminous sand bitumen, when extracted by carbon disulphide and then distilled, gave a coke residue of about 24% of the total bitumen. Examination of a sample of sand-coke residue from a retorting test on the bituminous sand, as such, showed that from 20 to 24% of the bitumen had been converted to coke. A destructive distillation of a sample of separated bitumen conducted in the Industrial Research Laboratory showed formation of coke to the extent of 22%. In the diagram, coke has been given an approximate value of 25%.

*S. C. Ells: "Bituminous Sands of Northern Alberta". Mines Branch, Ottawa. Report No. 281, p. 78.

The retorting of the bituminous sand is accompanied by the generation of gas. The quantity formed is not easy to estimate from the data available. Ells assigns 7½% of the bitumen to be accounted for by gas formation, and loss of distillate in the distillation test. A retorting test on 25 lbs. of bituminous sand showed the generation of 7½ cubic feet of gas. A rough calculation estimates this at 8% of the total bitumen present in the bituminous sand. The distillation test conducted in the Research Laboratory showed 10% to be accounted for by gas and loss of distillate. The quantity of gas has been given an approximate value in the diagram of 5%.

The crude distillate, when redistilled into fractions of gasoline, etc., leaves a residue of pitch in the retort. J. A. Kelso** found a residue of 7%. This value is approximated by data from other sources. About 5% of the total bitumen, then, is converted into pitch.

The fractions of gasoline, kerosene, and lubricants obtained from the fractional distillation of the crude distillate suffer very heavy losses when treated in the customary way with concentrated sulphuric acid to remove undesirable impurities. Ells places this loss at from 30 to 40%. An approximate estimation made in the Industrial Research Laboratory showed loss of gasoline, 40%; illuminating oils, 25%; and lubricants, 30%. Approximately 33% of the oil fractions, or 20% of the total bitumen is lost during refining.

Forty-five per cent. of the original bitumen finally comes through the manufacturing process as refined products. This will probably be divided among the various products as follows, calculating in round numbers from Kelso's analysis:

Gasoline	10%
Illuminating oils	30%
Light Lubricants	35%
Heavy Lubricants	25%

The gasoline and illuminating oils have a decided yellowish brown color, and the lubricating oil is a still darker brown. No mention has been made of a further complicating factor introduced by the presence of about 3% of sulphur in the natural bitumen.

A charge of inefficiency against the destructive distillation method of treating the bituminous sands seems warranted. It deliberately spoils the bitumen which the sand contains for use as an asphalt and then wastes half of it in the attempt to produce gasoline, illuminating oils and lubricants. About forty-five per cent. of the bituminous content of the bituminous sand is transformed into marketable products. This amounts to about eight per cent. by weight of the material which must be heated in the retorts. It does not follow, however, that, of necessity, the destructive distillation method cannot be made commercial. The world of industry provides many examples of wasteful processes which are nevertheless practised at a profit. A bituminous sand industry based on the destructive distillation method of treatment will, nevertheless, find it hard to successfully compete with the products manufactured from petroleum.

**J. A. Allan: "Mineral Resources of Alberta" (1920). Scientific and Industrial Research Council of Alberta. Report No. 2, p. 19.

CONCLUSION

Progress toward the development of the bituminous sand is still held up by a lack of a satisfactory separation process. A process is required which will liberate the bitumen from the associated sand cheaply and without altering its chemical nature. The most immediate economic application of the Alberta bitumen is as an asphalt. Asphalts are chiefly used in road construction; and one of the great needs of Alberta and the other prairie provinces is roads. The development of a type of bituminized earth road which would adequately meet the requirements of our rural highway traffic would at once open up a large outlet for the asphaltic bitumen contained in the bituminous sand. On the other hand, it is not improbable that the decreasing world supply of petroleum will eventually force industry to turn to such sources of bitumen as the bituminous sands for the manufacture of oils. Scientific research may any day discover really efficient methods of converting asphaltic bitumens into gasoline, kerosene and lubricants. Patents are being granted for processes which claim to have accomplished this result. The bituminous sand bitumen may even prove to be a source from which to prepare more valuable commodities than either asphalts or the refined mineral oils. But, whatever the future may disclose about ways of utilizing the bitumen, the first step in the process of development will be the operation of separating the bituminous sand in a way which does not commit the further treatment of the bitumen to the manufacture of one type of commodity, but which leaves the way open to its utilization for whatever purpose it is needed.

The views expressed in this article regarding the development of the bituminous sand are the views which are guiding the investigational efforts of the Industrial Research Department towards a solution of this problem. The experimental results of the past year make it hopeful that the Department may soon be able to announce the development of a separation process which will meet the requirements that have been laid down. Indications have also been observed which encourage the belief that the utilization of the bituminous sand bitumen for earth road improvement is capable of realization.

COLLECTION OF DATA

Ultimate Composition of the Alberta Asphaltic Bitumen in Comparison with Other Asphalts*

Asphalt	Sulphur %	Carbon %	Nitrogen %	Hydrogen %
Nevada	9.76	79.58	9.31	1.30
Trinidad	6.23	82.33	10.69	0.81
Bermudez	5.87	82.88	10.79	0.75
Alberta	2.73	84.49	11.23	0.04
Mexico	1.48	85.65	12.37	0.00
Texas	1.13	87.27	11.79	0.23

*(Table taken from Krieble & Seyer: J. Am. Chem. Soc., 43, 1339, (1921). Analyses of other asphalts are those chosen by C. Richardson as reference standards, J. Soc. Chem. Ind., 17, 29, (1898).)

Composition of the Alberta Asphaltic Bitumen Compared With That of Several Asphalts and Asphaltic Petroleum Residuals**

Constituents	Trinidad Asphalt %	Bermudez Asphalt %	Alberta Bituminous Sand Bitumen %	Residual from Mexican Asphaltic Petroleum %	Residual from Mixed Base Petroleum %
Asphaltous Acids and Anhydrides	10	6	2	1	1
Asphaltenes	37	35	23	6	trace
Asphaltic Resins	23	15	24	27	25
Oily Constituents	30	40	51	66	74

**Data for Alberta bitumen taken from Krieble & Seyer, J. Am. Chem. Soc., 43, 1339, (1921). Data for other asphalts taken from "Asphalts and Allied Substances," Abraham, p 546. Decimals have been eliminated. Asphaltic acids and anhydrides are determined by saponification with alcoholic potash in benzol solution and extraction by water; asphaltenes are precipitated from benzol solution by 88° Be. naptha; asphaltic resins are adsorbed from the 88° Be. naphtha solution by filtration through fullers' earth; the oily constituents remain in the benzol solution after the resins have been removed.

For the empirical formulae and physical constants of the hydrocarbons composing the oily constituents, see Krieble & Seyer, J. Am. Chem. Soc., 43, 1339, (1921).

For data regarding the proportion of bitumen in the bituminous sand and the grading of the sand at various points throughout the deposit, see "Bituminous Sands of Northern Alberta," S. C. Ells, Mines Branch, Ottawa, Report No. 281, p. 79. Also, "Mineral Resources of Alberta," (1920), J. A. Allan, Scientific and Industrial Research Council of Alberta, Report No. 2, p. 17.

PROPERTIES OF THE ALBERTA ASPHALTIC BITUMEN WHEN OBTAINED BY EXTRACTION OF THE BITUMINOUS SAND WITH CARBON DISULPHIDE*

	Ells	Abraham
Specific Gravity, 25°C./25°C.	1.018	1.022
Fixed Carbon	7.23%	10.55%
Bitumen soluble in Carbon disulphide		97.3 %
Free Mineral Matter		2.7 %
Bitumen soluble in 88°Be. naphtha	78.2 %	
Unsaturated hydrocarbons in 88°Be. naphtha	60.4 %	
Penetration:		
115° F.	too soft	
77° F. (100 gms., 5 secs.)	too soft	
(100 gms., 1 sec.)	9 mm.	
Volatile at 160°C., 5 hrs., New York Oven	11.2 %	
Properties of Residue:		
Specific Gravity, 25°C./25°C.	1.021	
Penetration:		
115°F.	too soft	
77°F. (100 gms., 5 secs.)	26.2 mm.	
Volatile at 205°C., 5 hrs., New York Oven	14.2 %	
Properties of Residue:		
Specific Gravity, 25°C./25°C.	1.025	
Penetration:		
115°F.	too soft	
77°F. (100 gms., 5 secs.)	12.2 mm.	
Volatile at 250°C., 4 hrs., New York Oven	18.8 %	
Properties of Residue:		
Specific Gravity, 25°C./25°C.	1.028	
Penetration:		
115°F.	too soft	
77°F. (100 gms., 5 secs.)	5.8 mm.	
Volatile at 500°F., 4 hrs., New York Oven		17.9 %
Properties of Residue:		
Specific Gravity, 25°C./25°C.		1.028
Penetration:		
77°F. (100 gms., 5 secs.)		5.2 mm.

*Data taken from "Bituminous Sands of Northern Alberta," S. C. Ells, Mines Branch, Ottawa, Report No. 281, pp. 77, 78; "Asphalt and Allied Substances," Abraham, p. 106.

Distillation Test of a Crude Distillate Obtained by Retorting Alberta Bituminous Sand*

Original Sample:

Water, by volume	3.2%
Sediment, tarry residue	0.5%
Oil, by volume	96.3%
Specific Gravity	19.5° Be.

Distillation of Oil:

1st Fraction	70 - 150°C.	9.7%	51.5°Be.
2nd "	150 - 230°C.	9.1%	36.5°Be.
3rd "	230 - 260°C.	4.9%	25.0°Be.
4th "	260 - 300°C.	13.3%	24.0°Be.
5th "	300 - 325°C.	18.6%	23.0°Be.
6th "	325 - 350°C.	14.0%	18.5°Be.
7th "	350 - 380°C.	23.0%	15.5°Be.
Residue and loss		7.4%	

Summary of Distillation Test:

Commercial gasoline	9.7%
Illuminating oils	27.3%
Light Lubricants	32.6%
Medium Lubricants	23.0%
Loss	7.4%

*Analysis by J. A. Kelso, Industrial Laboratory, University of Alberta, on a sample of crude distillate prepared and submitted by Dr. J. A. Allan.

COAL SAMPLES AND ANALYSES

Analyses of two classes of coal samples are given in the following tables. The first class consists of samples taken from the carload consignments received for testing at the laboratories of the University. This coal was taken at the mine by a provincial inspector of mines, and represents the commercial output of the mine at the time. Approximately half a ton was cut out from each 30-ton consignment by taking a shovelful of coal at regular intervals as the coal was unloaded from the carts at the University. This was then crushed, coned and quartered down repeatedly until a small laboratory sample was obtained.

The second class of samples are mine face, or channel samples taken from a working face of a mine by provincial mine inspectors to represent the output. The method adopted is that described in the first annual report of the Council, pages 17 to 19. It should be noted that the sampler is instructed to exclude from his sample all partings, bone coal, slate, etc., which in his judgment would be rejected by the miner and not included in the commercial shipments of the mine. This procedure tends to result in mine samples which are cleaner than the commercial shipments, although this is not always the case. The inspector takes one or more samples from each mine according to its output. In the larger mines he takes his samples in different working areas throughout the mine in such a way as to represent as closely as possible the average product shipped.

The mine inspectors also took a number of special samples from mine cars, box cars, tipples, etc., for comparison with the regular channel samples. These were analysed but the analyses are not included in the tables.

A complete proximate analysis was made of all the samples submitted, but ultimate analyses were made on only a few of these. The results of the latter are given in separate tables. The carload samples were analysed in the Research Council's laboratories. Other samples were analysed for the Provincial Mines Branch by Mr. J. A. Kelso, Provincial Analyst. In compiling the tables the samples are arranged geographically, classified according to the areas in which they occur. A specific name is given each mine whenever possible, but the number of the mine in the records of the Provincial Mines Branch is reported in all cases, thus: Carbondale No. 204. Where more than one regular sample had been taken from a mine at the same time, the results were averaged and only the average analysis is given. The number of samples represented by this average is stated. All samples were air-dried by exposure to the air in the laboratory until the loss in weight became negligible. The percentage moisture loss during air-drying is stated. The other analyses are those obtained on the air-dry coal. The fuel ratio quoted for each sample is the ratio obtained by dividing its percentage of fixed carbon by that of its volatile matter. This ratio gives an indication of the nature of the coal. The tables were compiled by Mr. J. B. Coghill.

Crow's Nest Pass Area

Name of Mine	Carbondale No. 204	Greenhill No. 396
Name of Operator	McGillivray Creek Coal & Coke Co.	West Canadian Collieries, Ltd.
Location of Mine	Coleman	Blairmore
Loss on Air Drying ......%	2.0	2.2
Proximate Analysis: (air dry coal)		
Moisture ......%	.3	.6
Ash ......%	16.4	13.9
Volatile Matter ......%	25.2	25.0
Fixed Carbon ......%	58.1	60.5
Sulphur ......%	.5	.6
Calorific Value: B.T.U. per lb. gross	12,360	12,740
Fuel Ratio	2.3	2.4
Kind of Sample	Average of 7 channel samples	Average of 10 channel samples
Sample taken by	Jas. Crowder	Jas. Crowder
Date of Sampling	February, 1921	Oct. and Dec., 1921

Crow's Nest Pass Area

Name of Mine	Greenhill No. 396
Name of Operator	West Canadian Collieries, Ltd.
Location of Mine	Blairmore
Ultimate Analysis: (air dry coal)	
Carbon ......%	69.3
Hydrogen ......%	4.2
Ash ......%	17.3
Sulphur ......%	.6
Nitrogen ......%	1.1
Oxygen ......%	7.5
Moisture in Coal ......%	.9
Kind of Sample	Channel
Sample taken by	J. Crowder
Date of Sampling	Oct., 1921

CANMORE-BANFF AREA

Name of Mine	No. 2	No. 80
Name of Operator	Canmore Coal Co.	Dept. Nat. Res. C.P.R.
Location of Mine	Canmore	Bankhead
Loss on Air Drying ....%	.5	.5
Proximate Analysis: (air dry coal)		
Moisture ....%	.6	.2
Ash ....%	7.7	10.9
Volatile Matter ....%	14.3	11.4
Fixed Carbon ....%	77.4	77.5
Sulphur ....%	.6	.5
Calorific Value: B.T.U. per lb. gross	14,090	13,500
Fuel Ratio:	5.4	6.8
Kind of Sample	Average of 8 channel samples	Average of 2 channel samples
Sample taken by	D. Shanks	D. Shanks
Date of Sampling	May, 1921	May, 1921

CANMORE-BANFF AREA

Name of Mine	No. 2	No. 80
Name of Operator	Canmore Coal Co.	Dept. Nat. Res., C.P.R.
Location of Mine	Canmore	Bankhead
Ultimate Analysis: (air dry coal)		
Carbon ....%	84.5	82.4
Hydrogen ....%	4.3	4.1
Ash ....%	5.9	9.6
Sulphur ....%	.6	.5
Nitrogen ....%	1.5	1.1
Oxygen ....%	3.2	2.3
Moisture in Coal ....%	.7	.1
Kind of Sample	Average of 2 channel samples	Channel sample
Sample taken by	D. Shanks	D. Shanks
Date of Sampling	May, 1921	May, 1921

BRAZEAU AREA

Name of Mine	No. 256	
Name of Operator	Brazeau Collieries	
Location of Mine	Nordegg	
Loss on Air Drying %	.5	
Proximate Analysis: (air dry coal)		
Moisture %	.3	
Ash %	11.3	
Volatile Matter %	16.6	
Fixed Carbon %	71.8	
Sulphur %	.4	
Calorific Value: B.T.U. per lb. gross	13,560	
Fuel Ratio	4.3	
Kind of Sample	Average of 6 channel samples	
Sample taken by	D. Shanks	
Date of Sampling	July, 1921	

BRAZEAU AREA

Name of Mine	No. 256	
Name of Operator	Brazeau Collieries	
Location of Mine	Nordegg	
Ultimate Analysis: (air dry coal)		
Carbon %	80.1	
Hydrogen %	3.9	
Ash %	11.9	
Sulphur %	.3	
Nitrogen %	1.2	
Oxygen %	2.6	
Moisture in Coal %	.2	
Kind of Sample	Channel sample	
Sample taken by	D. Shanks	
Date of Sampling	July, 1921	

MOUNTAIN PARK AREA

Name of Mine	No. 282	No. 693
Name of Operator	Mountain Park Coal Co., Ltd.	Cadomin Coal Co., Ltd.
Location of Mine	Mountain Park	Cadomin
Loss on Air Drying %	2.6	1.5
Proximate Analysis: (air dry coal)		
Moisture %	.0	.1
Ash %	14.6	15.2
Volatile Matter %	25.0	26.5
Fixed Carbon %	60.4	58.2
Sulphur %	....	....
Calorific Value: B.T.U. per lb gross	12,980	12,750
Fuel Ratio	2.4	2.2
Kind of Sample	Car load commercial sample	Car load commercial sample
Sample taken by	W. Shaw	W. Shaw
Date of Sampling	March, 1921	March, 1921

JASPER PARK AREA

Name of Mine	No. 280	No. 280	No. 429	No. 429
Name of Operator....	Jasper Park Collieries	Jasper Park Collieries	Blue Diamond Coal Co., Ltd.	Blue Diamond Coal Co., Ltd.
Location of Mine	Pocahontas	Pocahontas	Brule Mines	Brule Mines
Loss on Air Drying %	1.0	2.2	1.2	2.6
Proximate Analysis: (air dry coal)				
Moisture ....%	.3	.3	.2	.3
Ash ....%	16.4	16.5	18.7	19.0
Volatile Matter ..%	17.1	16.8	18.0	17.0
Fixed Carbon ....%	66.2	66.4	63.1	63.7
Sulphur ....%	.5	....	.4	....
Calorific Value: B.T.U. per lb. gross	12,790	12,750	12,350	12,400
Fuel Ratio	3.9	4.0	3.5	3.7
Kind of Sample	Average of 3 channel samples	Car load commercial sample	Average of 4 channel samples	Car load commercial sample
Sample taken by	W. Shaw	W. Shaw	W. Shaw	J. A. Richards
Date of Sampling	March, 1921	March, 1921	July, 1921	August, 1921
Remarks:	Mine since abandoned			

JASPER PARK AREA

Name of Mine	No. 280	No. 429
Name of Operator	Jasper Park Collieries	Blue Diamond Coal Co.
Location of Mine	Pocahontas	Brule
Ultimate Analysis: (air dry coal)		
Carbon %	71.4	74.2
Hydrogen %	3.5	4.0
Ash %	16.2	17.7
Sulphur %	.5	.4
Nitrogen %	1.2	1.3
Oxygen %	7.2	2.4
Moisture in Coal %	.3	.2
Kind of Sample	Average of 2 channel samples	Channel sample
Sample taken by	W. Shaw	W. Shaw
Date of Sampling	March, 1921	July, 1921

Saunders Creek Area

Name of Mine..........	Saunders Creek No. 388	Alexo No. 852	Saunders, Alta. No. 756
Name of Operator....	Saunders Creek Collieries, Ltd.	Alexo Coal Co., Ltd.	Saunders Alberta Collieries, Ltd.
Location of Mine......	Saunders	Saunders W.	Saunders W.
Loss on Air Drying %	2.3	3.0	3.0
Proximate Analysis: (air dry coal)			
Moisture ....%	4.9	6.6	5.4
Ash ....%	6.7	10.2	8.8
Volatile Matter..%	32.7	33.4	31.4
Fixed Carbon......%	55.7	50.8	54.4
Sulphur ....%	.3	.3	.4
Calorific Value: B.T.U. per lb. gross	11,730	11,180	11,300
Fuel Ratio	1.70	1.50	1.75
Kind of Sample	Av. of 3 channel samples	Channel sample	Channel sample
Sample taken by	J. A. Richards	J. A. Richards	J. A. Richards
Date of Sampling ..	October, 1921	October, 1921	October, 1921

YELLOWHEAD PASS AREA

Name of Mine	Foothills No. 771
Name of Operator	Foothills Collieries, Ltd.
Location of Mine	Foothills P. O.
Loss on Air Drying %	4.0
Proximate Analysis: (air dry coal)	
Moisture %	3.5
Ash %	12.4
Volatile Matter %	33.7
Fixed Carbon %	50.4
Sulphur %	....
Calorific Value: B.T.U. per lb. gross	11,390
Fuel Ratio	1.50
Kind of Sample	Car load commercial sample
Sample taken by	W. Shaw
Date of Sampling	November, 1921

LETHBRIDGE AREA

Name of Mine	Galt (No. 3) No. 3	Galt (No. 6) No. 3	No. 676
Name of Operator	Dept. Nat. Res. Can. Pac. Rly.	Dept. Nat. Res. Can. Pac. Rly.	Lethbridge Coal Co., Ltd.
Location of Mine	Lethbridge	Lethbridge	Lethbridge
Loss on Air Drying %	2.0	1.6	1.4
Proximate Analysis: (air dry coal)			
Moisture %	8.2	8.4	8.5
Ash %	9.1	10.3	10.0
Volatile Matter %	33.9	33.4	33.8
Fixed Carbon %	48.8	47.9	47.7
Sulphur %	.5	.5	.5
Calorific Value: B. T. U. per lb. gross	11,140	10,900	10,950
Fuel Ratio	1.45	1.45	1.40
Kind of Sample	Average of 5 channel samples	Average of 8 channel samples	Average of 4 channel samples
Sample taken by	M. Johnson	M. Johnson	Nat Howells
Date of Sampling	January, 1921	February, 1921	August, 1921

LETHBRIDGE AREA

Name of Mine	No. 174	No. 247
Name of Operator	North American Collieries, Ltd.	Chinook Coal Co., Ltd.
Location of Mine	Coalhurst	Commerce
Loss on Air Drying ....%	1.7	.7
Proximate Analysis: (air dry coal)		
Moisture ....%	8.5	8.9
Ash ....%	9.9	11.4
Volatile Matter ....%	32.9	33.5
Fixed Carbon ....%	48.7	46.2
Sulphur ....%	.5	.5
Calorific Value: B.T.U. per lb. gross	10,910	10,590
Fuel Ratio:	1.50	1.40
Kind of Sample	Average of 8 channel samples	Average of 5 channel samples
Sample taken by	M. Johnson	Nat Howells
Date of Sampling	January, 1921	August, 1921

Medicine Hat-Redcliffe Area

Name of Mine	Ajax No. 772	Redcliffe Coal Mine No. 165 and No. 765
Name of Operator	J. Oliphant	Redcliffe Brick & Coal Co., Ltd.
Location of Mine	Medicine Hat	Redcliffe
Loss on Air Drying ....%	6.7	6.8
Proximate Analysis: (air dry coal)		
Moisture ....%	18.5	17.4
Ash ....%	9.7	8.3
Volatile Matter ....%	32.9	32.5
Fixed Carbon ....%	38.9	41.8
Sulphur ....%	.5	.5
Calorific Value: B.T.U. per lb. gross	8,740	8,980
Fuel Ratio:	1.20	1.30
Kind of Sample	Average of 4 channel samples	Average of 4 channel samples
Sample taken by	Nat Howells	Nat Howells
Date of Sampling	October, 1921	October, 1921

DRUMHELLER AREA

Name of Mine	Monarch No. 402	Midland No. 367	Western Gem No. 678
Name of Operator	North American Collieries, Ltd.	Midland Collieries, Ltd.	Western Gem Mining Co., Ltd.
Location of Mine	Nacmine	Drumheller	Drumheller
Loss on Air Drying %	2.9	3.0	2.8
Proximate Analysis: (air dry coal)			
Moisture %	12.2	13.5	14.3
Ash %	7.4	8.1	11.7
Volatile Matter %	35.1	33.4	33.2
Fixed Carbon %	45.2	45.0	40.8
Sulphur %	.4	.4	.4
Calorific Value: B.T.U. per lb. gross	10,050	9,880	9,500
Fuel Ratio	1.30	1.35	1.25
Kind of Sample	Average of 6 channel samples	Channel sample	Channel sample
Sample taken by	D. Shanks	J. A. Richards	J. A. Richards
Date of Sampling	August, 1921	July, 1921	July, 1921

DRUMHELLER AREA

Name of Mine	Newcastle No. 317	Syndicate No. 898	Midwest No. 85
Name of Operator ..	Newcastle Coal Co., Ltd.	Gibson Syndicate	Midwest Collieries, Ltd.
Location of Mine	Drumheller	Drumheller	Drumheller
Loss on Air Drying %	2.6	3.0	1.8
Proximate Analysis: (air dry coal)			
Moisture ....%	12.7	13.5	14.7
Ash ....%	7.5	5.6	5.4
Volatile Matter ..%	34.2	37.3	34.3
Fixed Carbon ....%	45.6	43.6	45.6
Sulphur ....%	.4	.4	.4
Calorific Value: B.T.U. per lb. gross	9,940	10,185	10,160
Fuel Ratio	1.35	1.20	1.35
Kind of Sample	Average of 3 channel samples	Channel sample	Channel sample
Sample taken by	D. Shanks	J. A. Richards	J. A. Richards
Date of Sampling ..	August, 1921	July, 1921	July, 1921

DRUMHELLER AREA

Name of Mine..........	Callie No. 867	Celtic No. 697	Rose-deer No. 347
Name of Operator....	Callie Coal Co.	Celtic Coal Co.	Rose-deer Coal Mining Co.
Location of Mine......	Drumheller	Drumheller	Wayne
Loss on Air Drying %	3.0	2.6	2.0
Proximate Analysis: (air dry coal)			
Moisture ....%	14.6	12.9	13.9
Ash ....%	7.9	7.3	6.8
Volatile Matter..%	34.5	34.6	34.8
Fixed Carbon......%	43.0	45.2	44.5
Sulphur ....%	.4	.4	.4
Calorific Value: B.T.U. per lb. gross	9,875	10,050	10,000
Fuel Ratio	1.25	1.30	1.30
Kind of Sample	Channel sample	Channel sample	Channel sample
Sample taken by	J. A. Richards	J. A. Richards	J. A. Richards
Date of Sampling ..	July, 1921	July, 1921	July, 1921

Drumheller Area

Name of Mine	Monarch No. 402	Midland No. 367	No. 317	Rose-deer No. 347
Name of Operator	North American Collieries, Ltd.	Midland Collieries, Ltd.	Newcastle Coal Co., Ltd.	Rose-deer Coal Mining Co.
Location of Mine	Nacmine	Drumheller	Drumheller	Wayne
Ultimate Analysis: (air dry coal)				
Carbon %	58.9	59.9	60.8	59.8
Hydrogen %	5.4	5.2	5.3	5.2
Ash %	6.7	8.1	6.2	6.8
Sulphur %	.4	.4	.4	.4
Nitrogen %	1.3	1.3	1.3	1.3
Oxygen %	27.3	25.1	26.0	26.5
Moisture in coal %	12.0	13.5	13.9	13.9
Kind of Sample	Average of 2 channel samples	Channel sample	Channel sample	Channel sample
Sample taken by	D. Shanks	J. A. Richards	D. Shanks	J. A. Richards
Date of Sample	Aug., 1921	July, 1921	Aug., 1921	July, 1921

PEMBINA-WABAMUN AREA

Name of Mine	Pembina No. 227	No. 419
Name of Operator	North American Collieries Ltd.	Lakeside Coals Ltd.
Location of Mine	Evansburg	Wabamun
Loss on Air Drying %	2.5	3.4
Proximate Analysis: (air dry coal)		
Moisture %	16.4	16.3
Ash %	13.9	7.2
Volatile Matter %	27.6	32.8
Fixed Carbon %	42.1	43.7
Sulphur %	....	.2
Calorific Value: B.T.U. per lb. gross	8,750	9,330
Fuel Ratio:	1.50	1.35
Kind of Sample	Car load commercial sample	Average of 5 channel samples
Sample taken by	W. Shaw	W. Shaw
Date of Sampling	February, 1921	October, 1921

PEMBINA-WABAMUN AREA

Name of Mine	No. 419	
Name of Operator	Lakeside Coals, Ltd.	
Location of Mine	Wabamun	
Ultimate Analysis: (air dry coal)		
Carbon %	56.1	
Hydrogen %	5.1	
Ash %	5.7	
Sulphur %	.3	
Nitrogen %	.7	
Oxygen %	32.1	
Moisture in Coal %	16.8	
Kind of Sample	Channel sample	
Sample taken by	W. Shaw	
Date of Sampling	October, 1921	

LACOMBE AREA

Name of Mine..........	Maple Leaf No. 717	O'Connor No. 940	Beaver No. 717
Name of Operator....	Dan Shaw	W. P. O'Connor	Beaver Coal Co., Ltd.*
Location of Mine......	Castor	Castor	Castor
Loss on Air Drying %	8.0	7.5	8.0
Proximate Analysis: (air dry coal)			
Moisture ....%	19.8	19.8	19.8
Ash ....%	9.0	8.4	8.2
Volatile Matter..%	31.5	30.6	30.5
Fixed Carbon......%	39.7	41.2	41.5
Sulphur ....%	.6	.6	.5
Calorific Value: B.T.U. per lb. gross	8,660	8,740	8,760
Fuel Ratio	1.25	1.35	1.35
Kind of Sample	Channel sample	Channel sample	Channel sample
Sample taken by	J. A. Richards	J. A. Richards	J. A. Richards
Date of Sampling ..	November, 1921	November, 1921	November, 1921
Remarks:			*Mine now operated by Dan Shaw

LACOMBE AREA

Name of Mine..........	McCormack No. 275	Remillard No. 902	Halkirk Coal Mine No. 212
Name of Operator....	A. D. McCormack	T. B. Remillard	Richard Ruscoe
Location of Mine	Castor	Castor	Halkirk
Loss on Air Drying %	10.6	9.0	8.0
Proximate Analysis: (air dry coal)			
Moisture ....%	19.3	19.1	16.3
Ash ....%	8.6	6.4	8.6
Volatile Matter..%	33.8	32.1	31.2
Fixed Carbon......%	38.3	42.4	43.9
Sulphur ....%	.7	.7	.4
Calorific Value: B.T.U. per lb. gross	8,790	9,150	9,210
Fuel Ratio:	1.15	1.30	1.40
Kind of Sample	Channel sample	Channel sample	Channel sample
Sample taken by	J. A. Richards	J. A. Richards	J. A. Richards
Date of Sampling	November, 1921	November, 1921	November, 1921

LACOMBE AREA

Name of Mine	Hronek No. 427	Alfreda No. 273	Wadsworth No. 655	No. 660
Name of Operator ..	Ben Hronek	Davis & Green	Sam Wadsworth	J. F. Christopher
Location of Mine	Halkirk	Halkirk	Gadsby	Halkirk
Loss on Air Drying %	9.8	9.0	9.5	7.0
Proximate Analysis: (air dry coal)				
Moisture ....%	16.8	16.5	16.5	18.7
Ash ....%	8.8	6.0	9.1	5.8
Volatile Matter ..%	31.9	31.4	33.5	34.3
Fixed Carbon ....%	42.5	46.1	40.9	41.2
Sulphur ....%	.6	.5	.5	.5
Calorific Value: B.T.U. per lb. gross	9,100	9,370	9,090	9,190
Fuel Ratio:	1.35	1.45	1.20	1.20
Kind of Sample	Channel sample	Channel sample	Channel sample	Channel sample
Sample taken by	J. A. Richards	J. A. Richards	J. A. Richards	J. A. Rich-
Date of Sampling	Nov., 1921	Nov., 1921	Nov., 1921	Nov., 1921

LACOMBE AREA

Name of Mine	O'Connor No. 940	McCormack No. 275
Name of Operator	W. P. O'Connor	A. D. McCormack
Location of Mine	Castor	Castor
Ultimate Analysis: (air dry coal)		
Carbon %	52.0	53.1
Hydrogen %	5.5	5.4
Ash %	8.4	8.6
Sulphur %	.6	.7
Nitrogen %	1.0	1.1
Oxygen %	32.5	31.1
Moisture in Coal %	19.8	19.3
Kind of Sample	Channel sample	Channel sample
Sample taken by	J. A. Richards	J. A. Richards
Date of Sampling	November, 1921	November, 1921

CAMROSE-BATTLE RIVER AREA

Name of Mine	Bish No. 245
Name of Operator	Bish Bros. & Le Gear
Location of Mine	Forestburg
Loss on Air Drying %	6.8
Proximate Analysis: (air dry coal)	
Moisture %	19.0
Ash %	6.8
Volatile Matter %	33.1
Fixed Carbon %	41.1
Sulphur %	.3
Calorific Value: B.T.U. per lb. gross	9,110
Fuel Ratio:	1.25
Kind of Sample	Average of 4 channel samples
Sample taken by	W. Shaw
Date of Sampling	December, 1921

TOFIELD AREA

Name of Mine	No. 340
Name of Operator	Dobell Coal Co. of Tofield, Ltd.
Location of Mine	Tofield
Loss on Air Drying ....%	.......*
Proximate Analysis: (air dry coal)	
Moisture ....%	22.7
Ash ....%	5.0
Volatile Matter ....%	30.7
Fixed Carbon ....%	41.6
Sulphur ....%	....
Calorific Value: B.T.U. per lb. gross	8,780
Fuel Ratio:	1.35
Kind of Sample	Car load commercial sample
Sample taken by	W. Shaw
Date of Sampling	September, 1921
Remarks:	*This sample not fully air-dried

EDMONTON-CLOVER BAR AREA

Name of Mine..........	Twin City No. 177	No. 43	No. 699
Name of Operator ..	Donkin & Stevens Co.	Humberstone Coal Co.	Marcus Collieries, Ltd.
Location of Mine ..	Edmonton South	Beverley	Clover Bar
Loss on Air Drying %	4.7	4.1	8.2
Proximate Analysis: (air dry coal)			
Moisture ....%	22.1	18.4	17.9
Ash ....%	6.3	8.3	8.4
Volatile Matter ..%	29.2	31.7	33.0
Fixed Carbon ....%	42.4	41.6	40.7
Sulphur ....%	......	.3	.3
Calorific Value: B.T.U. per lb. gross	9,270	9,030	9,060
Fuel Ratio:	1.45	1.30	1.25
Kind of Sample	Car load commercial sample	Average of 5 channel samples	Average of 4 channel samples
Sample taken by	....	W. Shaw	W. Shaw
Date of Sampling....	January, 1921	August, 1921	October, 1921
Remarks:	Mine since abandoned		

EDMONTON-CLOVER BAR AREA

Name of Mine	No. 43
Name of Operator	Humberstone Coal Co., Ltd.
Location of Mine	Beverley
Ultimate Analysis: (air dry coal)	
Carbon %	53.8
Hydrogen %	5.6
Ash %	8.4
Sulphur %	.3
Nitrogen %	1.2
Oxygen %	30.7
Moisture in Coal %	18.1
Kind of Sample	Average of 2 channel samples
Sample taken by	W. Shaw
Date of Sampling	August, 1921

CARDIFF-NAMAO AREA

Name of Mine	Banner Mine No. 237	No. 397
Name of Operator	Banner Coal Co., Ltd.	Kelly Coal Co., Ltd.
Location of Mine	Cardiff	Carbondale
Loss on Air Drying ....%	6.5	5.3
Proximate Analysis: (air dry coal)		
Moisture ....%	18.3	19.8
Ash ....%	7.9	6.1
Volatile Matter ....%	32.5	32.9
Fixed Carbon ....%	41.3	41.3
Sulphur ....%	.4	.3
Calorific Value: B.T.U. per lb. gross	8,850	9,010
Fuel Ratio:	1.25	1.25
Kind of Sample	Average of 5 channel samples	Average of 4 channel samples
Sample taken by	W. Shaw	W. Shaw
Date of Sampling	October, 1921	December, 1921

CARDIFF-NAMAO AREA

Name of Mine	Banner Mine No. 237
Name of Operator	Banner Coal Co. Ltd.
Location of Mine	Cardiff
Ultimate Analysis: (air dry coal)	
Carbon %	52.5
Hydrogen %	5.7
Ash %	8.2
Sulphur %	.4
Nitrogen %	1.1
Oxygen %	32.1
Moisture in Coal %	19.1
Kind of Sample	Average of 2 channel samples
Sample taken by	W. Shaw
Date of Sampling	October, 1921

LIST OF PUBLICATIONS

Report No. 1

FIRST ANNUAL REPORT ON THE MINERAL RESOURCES OF ALBERTA (1919). pp. 104.

By Dr. J. A. Allan, Professor of Geology at the University of Alberta. This report contains a summary of the geological, economical and statistical information so far collected with regard to the mineral resources of Alberta, classified under the following headings:—

Bitumen,	Gypsum,	Petroleum,
Building Stone,	Iron,	Phosphate,
Clay,	Lead,	Potash,
Coal,	Mineral Springs,	Salt,
Copper,	Natural Gas,	Talc,
Gold,	Nickel,	Zinc.

Report No. 2

SECOND ANNUAL REPORT ON THE MINERAL RESOURCES OF ALBERTA (1920), pp. 138+14.

Dr. J. A. Allan supplements the information contained in the First Annual Report on the Mineral Resources of Alberta, and deals with the following:

Bituminous Sands,	Mica,
Building Stone,	Petroleum,
Clay and Clay Products,	Salt,
Coal,	Sodium Sulphate,
Iron,	Talc.

Report No. 3

FIRST ANNUAL REPORT OF THE ADVISORY COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH OF ALBERTA. (1920). pp. 36.

Includes: (a) A report by Prof. N. C. Pitcher on some aspects of the coal sitution in Alberta, to which are attached results of some screening and boiler tests made on Alberta coals at the University of Alberta; (b) Results of analyses by Mr. J. A. Kelso, Provincial Analyst, on coals collected in the Lethbridge and Crow's Nest Pass areas; (c) Report by Dr. J. A. Allan on a salt well drilled by the Alberta Government at Fort McMurray, and its carefully preserved core; and (d) Report by Dr. K. A. Clark on the problems involved in the improvement of Alberta highways, with a short note on the "Tar Sands."

Report No. 4

THIRD ANNUAL REPORT ON THE MINERAL RESOURCES OF ALBERTA (1921): GEOLOGY OF DRUMHELLER COAL FIELD, ALBERTA. By Dr. J. A. Allan. pp. 72 and map.

(Price $1.00).

This report deals with the geology of the coal measures, and the stratigraphic position, extent and variation of the coal seams that are exposed in the Drumheller district, a district which includes an area from Kneehills creek to the Rosebud river. The report is accompanied by a geological map showing the outcrops of all the coal seams, by profile sections showing the position of the coal seams, by stratrigraphic sections showing the relationship of the coal seams to the interbedded formations, and also by a plate which gives the cross section of the coal seams exposed in each of the mines in operation in the district.